CMFRI

WORKSHOP ON

MUSSEL FARMING

25 - 27 SEPTEMBER, 1980
MADRAS

CENTRE OF ADVANCED STUDIES IN MARICULTURE

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE

P. B. No. 1912, COCHIN-682 018, INDIA

TECHNICAL SESSIONS

11.15-13.00 Session I : PRESENT STATUS OF MUSSEL CULTURE

Chairman : Dr. R. Raghu Prasad

Rapporteur : Shri K. Nagappan Nayar

Background papers

CMFRI-CAS/MF/80/BP-1 An overview of the present status of mariculture: By E.G. Silas

CMFRI-CAS/MF/80/BP-2 Present status of exploitation of mussel resources in India: By K. Alagarswami, P.S. Kuriakose, K.K. Appukuttan and K. Rangarajan

CMFRI-CAS/MF/80/BP-3 Present status of mussel culture in India: By K. Nagappan Nayar

DISCUSSION

13.00-14.00 Lunch

14.00-15.30 Session II : BIOLOGY, PHYSIOLOGY AND GENETICS OF MUSSELS

Chairman : Dr. P.N. Ganapati

Rapporteur: Shri S. Mahadevan

CMFRI-CAS/MF/80/BP-4 Life history studies on Indian sea mussels: By K. Virabhadra Rao

CMFRI-CAS/MF/80/BP-5 Nutrition, growth and reproduction of mussels: By P.S. Kuriakose

CMFRI-CAS/MF/80/BP-6 Genetics of molluscs with special reference to mussels: By R. Natarajan

CMFRI-CAS/MF/80/BP-7 Some aspects of environmental physiology of raft grown mussels: By A.H. Parulekar and S.G. Dalal

DISCUSSION

15.30-15.45 Tea

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15.45-17.30 Session III : MUSSEL CULTURE TECHNOLOGY

Chairman : Dr. E.G. Silas

Rapporteur : Dr. P. Vedavyasa Rao

CMFRI-CAS/MF/80/BP-8 Criteria for site selection for mussel farms: By K. Rangarajan

CMFRI-CAS/MF/80/BP-9 Mussel seed collection and production: By S. Mahadevan

CMFRI-CAS/MF/80/BP-10. System design for mussel culture: By G.P. Kumaraswamy Achari

CMFRI-CAS/MF/80/BP-11 Farm technology : By P.S. Kuriakose and K.K. Appukuttan

DISCUSSION

26th September, 1980
Friday

09.00-11.00 Session IV : PRODUCTION AND ECONOMICS

Chairman : Shri G.N. Mitra

Rapporteur : Shri K. Rangarajan

CMFRI-CAS/MF/80/BP-12 Green mussel production and economics at Calicut: By P.S. Kuriakose

CMFRI-CAS/MF/80/BP-13 Brown mussel production and economics at Vizhinjam: By K.K. Appukuttan

CMFRI-CAS/MF/80/BP-14 Mussel production and economics at Kovalam (Tamil Nadu) : By S.J. Rajan

CMFRI-CAS/MF/80/BP-15 Mussel production and economics at Ratnagiri: By M.R. Ranade and Anil Ranade

CMFRI-CAS/MF/80/BP-16 Production and economics of mussels in Goa: By A.H. Parulekar

DISCUSSION

11.00-11.15 Tea

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11.15-13.00 Session V : SHELLFISH DISEASES AND CONTROL

Chairman : Dr. S.N. DWIVEDI

Rapporteur : Shri K.K. Appukuttan

CMFRI-CAS/MF/80/BP-17 Molluscan shellfish diseases : By K. Ramalingam

CMFRI-CAS/MF/80/BP-18 Predation and fouling problems in mussel culture: By S. Mahadevan

DISCUSSION

13.00-14.00 Lunch

14.00-15.00 Session VI POST-HARVEST TECHNOLOGY AND MARKETING

Chairman : Shri M.R. Nair

Rapporteur : Dr. P.S. Kuriakose

CMFRI-CAS/MF/80/BP-19 Public health aspects of culturing and processing of mussels and oysters: By S.T. Chari

CMFRI-CAS/MF/80/BP-20 Technology of processing mussel meat: By K.K. Balachandran and P.V. Prabhu

CMFRI-CAS/MF/80/BP-20a Marketing of mussels and its products

DISCUSSION

15.00-15.15 Tea

15.15-16.15 Session VII : SOCIO-ECONOMICS AND LEGAL ASPECTS OF MUSSEL FARMING

Chairman : Shri C. Chellappan

Rapporteur : Shri G.P. Kumaraswamy Achari

CMFRI-CAS/MF/80/BP-21 Socio-economic aspect of mussel farming: By S.J. Rajan and C.V. Mathew

CMFRI-CAS/MF/80/BP-22 Legal aspects of mussel farming: By A.D. Isaac Rajendran

DISCUSSION

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16.15-17.30 Session VIII : TRAINING AND EXTENSION

Chairman : Shri H.P.C. Shetty

Rapporteur : Shri S.J. Rajan

CMFRI-CAS/MF/80/BP-23 Extension of mussel farming: By K. Rangarajan and P.S. Kuriakose

CMFRI-CAS/MF/80/BP-24 Training requirements for the accelerated development of mussel farming

DISCUSSION

27th September, 1980
Saturday

08.00-13.00 Field visit to Mussel culture farm at Kovalam

13.00-14.00 Lunch

14.00-16.00 PLENARY SESSION

Chairman : Dr. E.G. Silas

Rapporteur: Dr. K. Alagarswami

RESUME AND RECOMMENDATIONS

Vote of thanks : Shri K. Nagappan Nayar

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TECHNICAL SESSION I PRESENT STATUS OF MUSSEL CULTURE | CMFRI-CAS/MF/80/BP-2

PRESENT STATUS OF EXPLOITATION OF MUSSEL RESOURCES IN INDIA

K. ALAGARSWAMI, P.S. KURIAKOSE, K.K. APPUKUTTAN AND K. RANGARAJAN
Central Marinr Fisheries Research Institute, Cochin-18

ABSTRACT

The two species of mussel, Perna viridis and P. indica, contribute to a sustenance fishery in India, particularly along the south-west coast. The paper deals with the characteristics of this fishery in the zones Ratnagiri to Gangoli, Cannanore to Calicut and Kovalam to Muttom and also at other dispersed centres. The magnitude of the fishery in terms of manpower, production means and production has been estimated. While admitting the limitations of the data presented, it is stressed that the figures are indicative of the scale of operations in the absence of more reliable data. A significant growth of the fishery has been recorded during last one decade and the landings as estimated have shown a three-fold increase. The paper also reviews the constraints and prospects for the future development of the mussel fishery.

INTRODUCTION

Hornell (1917, 1922) gave the first glimpses of the sea-mussel resources of India although references to their occurrence along the Indian coast have been made by earlier workers. Jones (1950, 1968) provided a detailed account of the mussel fishery of the west coast, with

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particular reference to the brown mussel. He (1950) had also suggested certain lines of inquiry on the mussel resources for better exploitation. A more detailed account of the resources and the magnitude of the fishery was given by Jones and Alagarswami (1973). These authors estimated the mussel production by the sustenance fishery around 1000 tonnes. Subsequent to the development of techniques of mussel culture in India (CMFRI, 1978) there has been a growing interest in the country on the exploitation of mussel resources more by culture techniques than by the tradtional fishery.

DISTRIBUTION AND EXTENT OF MUSSEL BEDS

The green mussel Perna viridis and the brown mussel Perna indica are the two species occurring along the Indian coasts. P. viridis enjoys a wider distribution along both the east and west coasts of India including the Andaman islands, whereas P. indica is restricted to the extreme south-west coast, from Varkala near Quilon to Muttom near Kanyakumari. The east coast is relatively poor for the mussel resource and exploitation is nearly absent except in a few centres such as Ennore and Kakinada. On the other hand, there is a rich resource on the west coast where the fishery is of considerable magnitude on the sustenance scale. The mussel distribution follows the presence of coastal or submerged rocks which form its habitat. Based on abundance and level of exploitation, both of which show close correlation, three zones could be delineated along the west coast - a) Ratnagiri to Gangoli, b) Cannanore to Calicut, and c) Kovalam to Muttom. Along the east coast the mussel-bearing rocks are far between and, therefore, no such zonation could be made.

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Ratnagiri to Gangoli

This zone lying in the maritime States of Maharashtra, Goa and Karnataka has a dispersed distribution of the green mussel P. viridis which is exploited by the fishermen of the localities on a low sustenance scale. The granite mussel beds are fewer and are submerged. Around Ratnagiri, the green mussel is found in Bhatia Creek, Purnagad, Goa Khadi, Goclamkeri, Bathkarwada, Jayatapur and Sakunata. Near Malwan, mussels are collected at Deogad, Mohar and Kochra.

As reported by Rao et al. (1975), P. viridis occurs in Goa scattered all along the coastal region at the river-mouths of Tirakol, Chapora, Mandovi and Zuari. It is in fair abundance in Chapora, Anjuna, Calangute, Aguada, Miramar, Dona Paula (including Cabo-Raj Nivas) and Velsao. In these areas mussels are found over the laterite rocks and granite boulders, sometimes thickly set and sometimes sparse (Rao et al., 1975).

Around Karwar, the mussel is found in Hanavar-Mullukarve, Shedeguli, Gudiangadi, Holangadde, Gangavali, Belambare, Chendia, Binage, Kamath's Beach, Nichanhippal-Majali and around Kuramgad Islands in Karwar Bay. Philippose et al. (1980) have reported that the most important mussel beds of this area are located in Shankarbag, Devagad and Kuramgad areas. In Dakshina Kannada section of the Karnataka coast mussel-bearing rocks are scattered from Gangoli to Kap.

Cannanore to Calicut

The coast of Kerala from Cannanore to Calicut is the virtual mussel zone of India where the abundance of P. viridis and its exploitation are at maximum. Intertidal and submerged laterite or granite rocks form the habitat of the mussel. Table 1 gives details of the mussel fishing centres of this zone along with information on the approximate extent of beds, potential stock and estimated production.

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The data have been collected based on detailed enquiries with the knowledgeable local fishermen engaged in mussel fishing at different centres and also from random samples of mussels collected from various beds.

Mussels occur on the coastal rocks in the intertidal zone, man-made granite protection walls and submerged rocks which are either scattered or form continuous stretches of a few kilometres distance and extend in depth upto 12 metres. Collection of mussels is normally restricted to the upper 5 metres in view of abundance of mussels up to this depth and limitations of physical endurance of the divers. The total extent of mussel beds in this zone is approximately 2218 ha, of which 143 ha are in the intertidal region and the rest on the submerged rocky stretches.

Although the limitations of the projections given are admitted and the figures are subject to revision in future, they are indicative of the magnitude of the fishery potential in the absence of more reliable data. In terms of area, the beds at Thikkodi and Moodadi, Chombala, Mahe, Koduvally and Tellicherry are of considerable importance.

Kovalam to Muttom

This zone which is partly in Kerala and partly in Tamil Nadu is well known for the fishery of the brown mussel Perna indica (Jones, 1950). The habitat occupied by the brown mussel is similar to that of green mussel, namely intertidal and submerged rocks. But the coast is exposed to exceptionally heavy seas during the monsoon and in spite of this the mussel thrives in great abundance on rocks from low tide to a depth of up to 15 m. During the recent years, the green mussel P. viridis is also found in this zone to the extent of 5% of the total population. The mussel fishing centres in this zone are Kovalam, Avaduthura, Pulloorkonam, Vizhinjam, Kottappuram, Karimpally, Mulloor,

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Pulinkudi, Chowhara, Enayam, Colachel, Kadiapatnam and Muttom. No estimates have been made on the extent of mussel beds in this zone.

Apart from the centres mentioned above, mussel fishery at a low sustenance level is conducted at some centres, such as Chilakkoor, Papanasam and Vettoor near Varkala (south of Quilon), Valiathura near Trivandrum and Kodimunai, Vanikudi, Kurumpanai, Enayam, Enayam-Puthenthurai, Ramanthurai and Kovalam (near Kanyakumari). This fishery is dependent on the brown mussel and the beds are limited in extent. In some centres the mussels are found on the concrete pillars of harbour structure as at Valiathura and Fort Cochin, breakwaters (tetrapod structures) as at Vizhinjam and wave breakers at Varkala.

A recent development relating to the mussel resources is the settlemtnt of green mussel on the stone embankments and groynes laid as an antierosin measure along the central coast of Kerala. This resource was identified by Jones and Alagarswami (1973) and surveyed by Nair et al. (1975). At several centres mussels are collected from these rocks either for domestic consumption or for sale.

Along the east coast, mussel resource (P. viridis) as known at present is restricted to a few centres. On the coast of Tamil Nadu, mussels are found at Porto Novo, Mahabalipuram, Cuddalore, Pondicherry and Ennore of which only the estuarine bed at Ennore is of some importance. At other centres, these are found on concrete pillars of jetty and side walls. In Andhra Pradesh, the only known mussel bed is at Kakinada Upputeru to an extent of 1.5 km along the creek. In Orissa, the green mussel is found in the Sonapur backwater on the river Bahudha, conjointly with the edible oyster. From the Andamans, P. viridis has been recorded from Chippighat near Port Blair.

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MAGNITUDE OF MUSSEL FISHERY AND PRODUCTION

The mussel fishery of India is of a sustenance nature and is slightly more evolved in the form of a trade in the Cannanore-Calicut Zone with a concentrated market in Calicut. Jones (1950, 1968) has given detailed account of the mussel fishery. The divers reach the mussel beds either by swimming or in canoes depending on the distance of beds and collect the mussels either by handpicking or with sharp tools like chisel. Invariably each diver has a bag tied around his waist in which he keeps the mussel till he surfaces after a dive. Women and children collect mussels from the intertidal rocks. No improvements on the methods of fishing have taken place except that some use locally made masks while diving.

Manpower employed

Jones and Alagarswami (1973) gave some estimate of manpower employed in mussel fishery. According to them, about 24 to 36 persons are in mussel fishing in Ratnagiri, Malwan and Karwar; 250 full-time and 75 off-time workers in the zone Cannanore to Calicut; and about 690 persons in the Kovalam - Muttom Zone.

Current estimations have been made on this aspect for the last two zones. In the Cannanore-Calicut zone 335 persons are engaged actively in the mussel fishery out of a total 530 mussel collectors. These persons are distributed among the 16 centres referred to in Table 1. Fifty active mussel pickers are from Chombala, 35 from Badagara, 30 each from Koduvally, Mahe and Challium, 25 from Muttungal, 22 from Poyilkavu, 20 each from Tellicherry and Thallai and the rest from other centres. In the Kovalam-Muttom Zone about 790 persons are engaged in mussel picking, of whom 340 are from Vizhinjam area including the centres of Kovalam, Avaduthura, Pulloorkonam, Vizhinjam

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and Kottappuram, 225 are from Karimpally, Mulloor and Chowhara, and 225 are from Enayam, Colachel, Kadiapatnam and Muttom. Of the total 790 fishermen, 520 are engaged actively in mussel fishing. Between Varkala and Trivandrum about 45 persons collect mussels.

These figures add up to a total manpower of about 1400 persons engaged in mussel fishing along the west coast. Along the east coast, the manpower may not exceed about 100 persons, including about 50 in Kakinada. Thus mussel fishery offers employment to about 1500 persons in the country, It has to be stressed that the mussel fishing activity is confined only to part of the year, generally November to May along the west coast, with peak season during December-February at most of the centres, and during the rest of the year, they are engaged in other types of small fishing operations or diving for chanks. Even during the season, on many days they go for fin-fishes. All the major religious communities in the coastal region are represented in the manpower and Harijans also from part of it at some centres. Including the dependents, the mussel fishery can be considered to sustain the livelihood of a coastal population of not less than 5000 persons. Compared to the estimations given by Jones and Alagarswami (1973), there has been a considerable increase in the manpower engaged in mussel fishery presently, by approximately 20% which would indicate one aspect of the growth of this fishery.

Production means

Canoes and Catamarans form the main base of the means of production along the west coast. Simple logs are used at Thikkodi and carvel-built boats in Kakinada. The estimates of Jones and Alagarswami (1973) were 170 canoes and 50 logs for the Cannanore-Calicut Zone and 295 catamarans for the Kovalam-Muttom Zone. The present estimates are 307 canoes and 10 logs in the Cannanore-Calicut Zone which shows a considerable increase over the previous figures. Revised estimates have not been made for the other zones.

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Production

Jones and Alagarswami (1973) have given an estimated production of 823.4 tonnes of mussels, of which 321.0 tonnes were contributed by the green mussel and 502.4 tonnes by the brown mussel. According to them, given the limitations of the study, an estimate of about 1000 tonnes would not be wide of the actual figures. Some efforts were made in the present study to update the landing figures through detailed enquiries.

The estimates of production for the Cannanore - Calicut Zone have been given in Table 1. The annual landings of the green mussel in the zone are 2615 tonnes. Chombala, Thikkodi - Moodadi and Mahe are the most important centres, followed by Koduvally and Tellicherry. In terms of extent of mussel bads, manpower employed and canoes used these centres have a lead over others. As against the estimated potential harvest of 7910 tonnes, the present exploitation is only 33.06%, that is one-third of the potential. The average production in the total 2218 ha of mussel beds works out to only 1.18 tonnes which is pitifully low.

The size of mussels harvested and marketed range 40-120 mm, majority of the mussels averaging 75-100 mm.

In the southern zone Kovalam - Muttom, the annual landings of brown mussel have been estimated at 427 tonnes, of which 183 tonnes come from the Vizhinjam area (Kovalam to Kottapuram), 76 tonnes from Mulloor - Chowhara area and 168 tonnes from Enayam-Muttom area. The potential harvestable stock in the first two areas have been estimated to be about 900 tonnes. The landings in these areas account for only 28.8% of the potential stock. The yield in terms of area works out to about 14.9 tonnes per ha.

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TABLE 1. Extent of mussel beds (ha) and estimated annual production (tonnes) at different centres in the Cannanore-Calicut Zone.

Centre	Extent of mussel beds (ha)		Estimates of production(t)	
	intertidal	deeper water	Exploited	Potential
Azhikkal	-	9	15	30
Cannanore (Moppila Bay)	3	20	12	40
Mythanapally	-	20	36	60
Koduvally (Dharmodom)	5	200	260	900
Tellicherry	30	125	220	600
Thallai	20	80	180	400
Mahe	30	300	360	1100
Chombala	-	400	600	1200
Muttungal	-	80	125	380
Badagara	-	5	13	30
Thikkodi & Moodadi	40	700	420	2400
Kollam	4	16	20	100
Poyilkavu	3	10	26	60
Elathur	3	30	88	160
Calicut (South Beach)	-	20	90	100
Challium & Beypore	5	60	150	350
Total	143	2075	2615	7910

The size of mussels harvested remains small at 40-85 mm. Due to the great demand for mussels, there has been indiscriminate fishing resulting in the removal of stocks before they reach the normal harvestable size. The large sized mussels, called 'Muthuva', in the range 70-90 mm contribute only to a small portion of the landings.

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Revised estimates of production have not been made for other centres, except that the annual production of the Ennore bed may be around 5-7 tonnes and from other centres of Tamil Nadu about 5 tonnes.

In the light of the data presented here it is worthwhile to update the Indian mussel production figures against those provided by Jones and Alagarswami (1973) which were based on data collected in 1968. In the case of centres for which current figures have not been estimated, a nominal increase of 10% over the figures given by Jones and Alagarswami (1973) has been made. The data are presented in Table 2. The total estimated annual production of mussels is about 3079 tonnes. This is over three times the estimate of Jones and Alagarswami (1973). It has been mentioned earlier that the production accounts for only about one-third of the potential stock in the two important mussel zones of the south west coast. The scope for increasing production to thrice that of the present level becomes evident.

TABLE 2. Estimates of mussel production (annual landings in tonnes) in India.

Zone/Centre	Species	Production (t) of mussels (Shell-on)
Ratnagiri to Gangoli	*P. viridis*	17
Cannanore to Calicut	*P. viridis*	2615
Kovalam to Muttom	*P. indica*	427
East Coast Centres (Cuddalore, Pondicherry, Ennore and Kakinada)	*P. viridis*	20
Total		3079

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CONSTRAINTS AND PROSPECTS FOR DEVELOPMENT OF MUSSEL FISHERY

With the availability of technology for mussel culture, the development efforts in future would be towards encouraging production of mussel through farming, particularly in view of the fact that the yield in culture is very high. However, till an organised industry with capital and all infrastructure facilities develops, the natural fishery will continue to play its role. It has been the experience in India that the artisanal fisheries cannot be totally replaced by modern fishing techniques and this might also be relevant to the mussel fishery.

The present mussel fishery is at sustenance level and is carried out by certain families traditionally engaged in mussel picking. The fishery is carried out only during fair weather outside monsoon and mostly it is a part-time occupation. Except in Cannanore-Calicut and Kovalam-Muttom zones, the fishery is of a casual nature. The mussel divers in the Colachel-Muttom area prefer to go for Chank diving which gives higher returns than for mussel collection. The governmental assistance to mussel fishery is nil. There is an urgent need to have a fresh look at the problems of the mussel fishery and assist its development in view of the fact that it supports the livelihood of a few thousand people in the coastal sector.

The production problem will relate to providing assistance towards canoes/catamarans which form the only inventory requiring capital. Marketing of mussels is another aspect which deserves attention. In view of the demand in centres such as Vizhinjam and Calicut the daily collection of mussels are sold out readily but it is not so at other centres. Trucks are engaged to move the mussels from as far as Mahe to Calicut and therefore a good portion of the returns goes to the hands of middlemen who are engaged in the trade. There is

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no organised set-up among the mussel pickers for taking care of their interests.

Some efforts have already been made towards development of processed products of mussels. This needs further attention to put them into commercial practice. At present the mussels are marketed fresh without subjecting them to any purification process. Simple and effective depuration techniques will have to be evolved and practised to maintain higher hygenic conditions. Serious efforts must be made for exploring export market for the mussel products so that more remunerative price could be realised for the raw mussel. There is also need for enlarging the consumer sector through appropriate demonstrations and follow-up action.

Further development of the mussel fishery towards realising the indicated potential would largely depend on providing the services mentioned above on a collective or cooperative basis. This could be attempted at least at the most important centres of mussel fishery in the Cannanore-Calicut and Kovalam-Muttom zones to begin with and extended to other centres on a planned programme.

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TECHNICAL SESSION I PRESENT STATUS OF MUSSEL CULTURE	CMFRI-CAS/MF/80/BP -3

PRESENT STATUS OF MUSSEL CULTURE IN INDIA

K. NAGAPPAN NAYAR
Central Marine Fisheries Research Institute, Cochin - 18

INTRODUCTION

The technique of raft culture of mussels developed and practised in Spain and followed by other European nations is a stimulating example of the higher efficiency of resource use, technically feasible to achieve several-fold increase over the level of natural bed production. This motivated the efforts in India too to develop mussel production in a manner quite different from the conventional path in which we have moved so far. This was all the more made easy since all along our coastal regions there are large unexploited or not yet fully utilised mussel population. Further, the most promising way of converting marine phytoplankton into animal protein is to culture shellfishes as they feed on products which are only one step down in the food chain. The great resilence, rapid growth and easy harvesting of mussels together with the additional plus factors in our waters with regards absence of pollution and /to

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high productivity of waters warranted the mariculture attempts on mussels. This culture attempt by CMFRI commenced less than a decade ago, in 1971 at Vizhinjam where seeds of the brown mussel Perna indica were collected from nearby natural beds and seeded on to ropes of different lengths and suspended from rafts. Success was achieved by obtaining a five-fold greater production, in a shorter duration when compared to natural bed yield. This paved way for extending the rope culture technique for green mussel culture at Calicut and Madras too so as to evolve appropriate technique of culture depending on respective local conditions. The effort at Calicut was by and large a great success since the yield of green mussel here was as much as eight times the seed weight in a very short period of 150 days. Several obstacles encountered here and there during the course of farming experiments are being studied and solved so that standardisation of techniques in all aspects can be done in a few years time from now.

In addition to the work that is being done by CMFRI, attempts are also being made to study the various problems connected with mussel culture by the Konkan Krishi Vidyapeeth at Ratnagiri and also by the National Institute of Oceanography at Goa. The success obtained at Vizhinjam on mussel culture helped the Fisheries Department of the Government of Kerala to take up a Pilot Project on mussel culture at Vizhinjam in 1975.

REVIEW OF THE MUSSEL CULTURE WORK IN THE WEST AND EAST COAST

I. West coast:

a) Vizhinjam: Culture of the brown mussel Perna indica at

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Vizhinjam is a semi-culture in the sense the seeds are collected from the natural setting grounds and grown on floating rafts till they attain marketable size. The initial experiments were conducted inside the bay area, which is well protected from the strong wave action during the monsoon season. Seeded ropes suspended from the rafts showed very good growth. Based on interesting preliminary results obtained, attempts were made from 1978 onwards to carry out mussel culture in the open sea. Rafts of different sizes, ranging from 6 x 6 m to 10 x 10 m were fabricated with teak and bamboo poles lashed together by coir or nylon ropes were tried. Oil barrels of 200 litre capacity treated with anticorrosive paint, were used as floats to give the required buoyancy for the rafts. The rafts were individually moored by anchors using the required length of anchor chain. In the bay area it was possible to keep the raft in position throughout the year, but in the open sea it was possible only during December to May when the sea is fairly calm. The experiments in the open sea were carried out 1-2 km away from shore at a depth of about 20 m. The brown mussel at Vizhinjam area normally spawns during the month of May, prolonging till September. As it was found that seed mussels of 20-35 mm size are better suited for seeding purposes, the collection of seed from the natural rocky beds is best done during September-November period. Different types of spat collectors were also tried inside the bay for the collection of spat. Split ropes suspended from the rafts gave good results.

Seeding technique:

The seeds were wrapped around coir or nylon rope and secured by cotton netting or bandage cloth. It was observed

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that as the seed attach well and grow on nylon ropes it will be more economical to use nylon ropes. For seeding purposes 1.4 to 2 kg of seed were used per meter length of rope. In the open sea about 10 m. long rope were seeded depending on depth of the water. The seeded mussels suspended from the raft attach very soon to the rope and the outer cloth used for keeping them in position disintegrate. In the Bay area it was observed that the mussels reach marketable size of 55-60 mm in a period of 8 months showing a rate of growth of 2.9 to 3.5 mm per month giving a meat value of 41% at the time of harvest. In the open sea, 60-65 mm size was attained in 5 months and the rate of growth was about 5.5 mm per month. It was also seen that the production was 10-12 kg of mussel per metre length of rope in the bay area in 7 months, whereas in the open sea it was 15 kg for a 5 month-period.

(b) Calicut: Mussel culture work is being done at Calicut for the past 5 years. The technology of culture of the green mussel P.viridis that was being tried was basically the same as that of Vizhinjam with slight modifications to suit the local conditions. Rafts of surface area of 275 sq. meters were cloated in the open sea at a depth of 8 metres. Mussel seed (10 to 20 mm size) collected from the local natural mussel beds were used for seeding ropes. These seeded ropes were suspended from each raft and 750 gm. of seed were used per length of rope. Usually 7 metre of rope was seeded since the depth where the rafts were moored was only 8 m. The mussels grew at the rate of 14 mm per month and attained a size of 85.5 mm in a period of 5 months. The rate of growth of the mussels in the natural bed was slower being only 6.5mm per month. The initial average

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weight of .85 gm/per mussel increased to 29 g. during this period. While harvesting, an average weight of 82 kg of mussel was achieved on single rope thus showing an average production rate of 12.3 kg of mussel per metre of rope. Instead of each raft being separately anchored, a few of them were serially connected for easy management. Following the success of the experiments, a demonstration project was started in 1978.

c) Goa: Work was initiated by the National Institute of Oceanography at Goa in April 1974 (Qasam et al, 1977) and the raft method of culture was followed. Based on the experiments conducted it was observed that a raft of 2.5 x 2.5 m could accommodate 40-60 mussel ropes of 3 m length with 2.5 m seeded portion. The seeded mussels grew to a size of 85 mm in all month period recording an average growth of 8 mm/month. In the natural bed at Goa it was observed to be only 5 mm/month. In the farm the harvestable size of 60-64 mm was attained in 5 months time. Based on the observation carried out for a peiod of 1 year from 2 rafts having about 120 ropes of mussels the economics have been worked out (Qasim et al, op.cit) which gives a return of 181% of the capital amount within a period of one year. As most of the materials could be used again for another one or two years with slight expenditure on maintenance of the raft, it was assumed that the yield for the next two years would be much higher although the same has not been mentioned by them.

Rao et al (1976) carried out experiments on spawning, fertilization and larval development of the green mussel at Goa. They were able to study the early developmental stages only up to the setting stage. Efforts to achieve complete

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success up to spat settling stage and spat growth are necessary to evolve a sound seed production technique under controlled conditions. Attempts are being made at present at Madras and Vizhinjam by the CMFRI to perfect the hatchery technique where some initial success has been achieved but the technology is yet to be perfected.

II. East coast:

a) Madras: At Madras also the technology of green mussel culture is more or less the same as done at Calicut and Vizhinjam. This work was initiated by CMFRI in January 1973 at Ennore estuary where the depth of water was about 2 m. Being a shallow area fixed rafts were constructed by means of wooden poles and mussel seed collected from the nearby natural beds were used in preparing the usual type of mussel ropes and were suspended from the raft. Although the mussel seed got attached to the ropes and grow very well within a short period the silting in that area appeared to be very heavy gradually resulting in total mortality of mussels in the farm. A growth rate of 9 mm per month was observed. As the site appeared to be unsuitable for mussel culture, the work was shifted to Kovalam bay where the conditions appeared to be more favourable. At Kovalam instead of having fixed raft system the rafts were floated by means of suitable oil barrels and moored by anchors and anchor chains. Seed were collected from Kovalam natural beds and also from Ennore. The rate of growth at Kovalam appeared to be rapid and within a period of 4 months the mussels attained a marketable size of 70-75 mm, registering a growth rate of 13 mm/month. A raft with 50 ropes of 6 m length each gave a 2 ton production within a period of

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4 months. As Madras coastal zone is a cyclone-prone area affecting the coast during May-June and or October-December, it was felt necessary to evolve a stable raft system like submersible rafts. Such rafts with conical floats are at present being tried, so that the rafts could withstand any type of rough sea.

An attempt was also made at Kovalam, Madras to follow 'Bouchot' method of mussel culture (Stake culture on intertidal flats). But this method had to be abandoned as the posts could not be kept in position in the sea bed on account of wave action and intense fouling.

b) Waltair: Although attempts to culture green mussels were made at Waltair they did not give any encouraging results. The rafts which were floated there could not withstand the strong wave action most of the months with the result that there has been always difficulty in mooring the rafts in position.

c) Tuticorin: During 1975 and 1976 experimental culture of mussels brought from Cape Comorin and Cuddalore was attempted in the Harbour basin at Tuticorin by suspending seeded ropes from 5 x 5 m raft. The growth was poor and the seed falling off the ropes was one of the main problems. Even after 9-10 months the mussels did not attain sexual maturity and the meat content was very low. It was thought the general paucity of phytoplankton might be one of the controlling factors. The experiments had to be discontinued as the area was considered unsuitable. Transplanting seeds on granite boulders also met with little success since the predation by perches like Gaterin sp. Teuthis spp wiped out the stock.

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PROBLEMS AND PROSPECTS

Although different methods like bottom culture, bouchot culture, raft culture, rack culture and pole culture are being followed in different countries only 'raft culture' technique was tried in India considering the high yield known from this three dimensional culture environment. In France, it takes 2 years for cultured mussels to reach the marketable size of 40-50 mm. In Yugoslavia it takes 15-18 months for the harvest size of 70 mm to be attained. Culture experiments at Calicut and Vizhinjam have shown that the green mussels reach 75 mm size in less than 6 months and the brown mussels grow to 55-60 mm in 8 months. Comparatively this is a very rapid growth. The spanish raft system can yield 50-60 tons (Andrew, 1968) per raft which is a very good production rate. But under Indian environmental conditions the indications are that the production may over-reach the achievement recorded in Spain. Per hectare production has been calculated to be as high as 450 tons at Calicut.

Weighed against these advantages some of the difficulties and bottlenecks encountered during the course of experiments remain to be satisfactorily solved before culture industry can be established on profitable lines. The first of these concerns fabrication of an all-weather proof raft to stand against the fury of the monsoon winds and waves during June-August in the west coast and November-December in the east coast. Year after year rafts had been lost alongwith the growing stock of mussel because of this factor. To overcome this difficulty attempts are being made

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at Madras to find out the suitability of a sumbersible raft system floated at sub surface level. This can minimise the stress on the raft. An alternate method which is being thought of is the use of synthetic pliable poles for the raft frame work which will offer very little resistance to riding waves and swells. Long-line culture, as is done for oysters in Japan, might also help to solve the problem. But this requires selection and identification of areas clear of navigation and traditional fishing activities. This is yet to be attempted in India.

Problems of sewage and industrial contamination in the coastal areas do not at present hold out serious problems. But this has to be kept in view while future expansion is planned. Monitoring the environmental conditions and studying the physico-chemical characteristics of the farm areas is absolutely essential to keep track of the changes in the quality of water. Mussels can accumulate fairly high concentration of metals like zinc, copper and mercury in the tissue. Though these are not lethal to the mussels, human consumption of mussel meat in which these are stored might have serious consequences.

Very often mussel seed fall off the ropes due to some unknown reasons and studying the interaction of invironmental variables, mussel physiology and behaviour thus seems desirable to devise methods to avoid this.

Problems of processing technology and marketing are also to be properly studied and standardised. Purification of mussels after harvest appears feasible to reduce the bacterial load. It is known that some bacteria in the flesh

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can survive prolonged refrigeration and under normal storage conditions may multiply also. The usual cooking methods may destroy some of the bacteria but thorough studies are needed to gain precise knowledge on the above aspects. Sanitary control of mussel farm area is also desirable for which regulations and norms are to be stipulated based on the above studies.

Unlike oyster meat, mussel meat enjoys popularity amongst different sections of Indian people. Consumer preference and demands should be ascertained through market surveys. Extension wing remains to be developed to popularise mussel farming techniques among fishermen and mussel eating habit among people who are not aware of the nutritional richness of its meat. Creating a stable internal and export market depends on the standardisation of the quality of products and the cheapness of the material offered to the market. Priority attention should be given to efforts to achieve the above objectives. Although our culture experiments have established the feasibility of farming, the above problems are to be satisfactorily solved to put industry on economically viable lines.

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CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
COCHIN - 682 018
CENTRE OF ADVANCED STUDIES IN MARICULTURE
WORKSHOP ON MUSSEL FARMING
MADRAS 25-27 SEPTEMBER 1980

TECHNICAL SESSION II	BIOLOGY, PHYSIOLOGY AND GENETICS OF MUSSELS	CMFRI-CAS/MF/80/BP-4

LIFE-HISTORY STUDIES ON INDIAN SEA MUSSELS

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Mussel culture operations are in good progress at the demonstration farms of the Central Marine Fisheries Research Institute at Vizhinjam and Calicut along the west coast and at Kovalam near Madras on the east coast. Experimental mussel farming is also undertaken by the National Institute of Oceanography at Dona Paula in Goa and at Ratnagiri by the Agricultural University of Maharashtra. Biological studies of an academic nature are being carried out at the University of Madras and Aurangabad. It has been shown that the yield rates are high enough to bring fair profits after covering the initial investment for building up farming facilities and recurring maintenance expenses. Some of the coastal fishermen have now learnt to supplement their income from regular fishing by taking to mussel culture under the technical guidance of the staff of the Central Marine Fisheries Research Institute.

Mussels are hardy to fluctuations in environmental conditions to a great extent and are fast growing. Being filter feeders, the mussels feed upon the phytoplankton, the first in the food chain, and build up highly proteinaceous meats which are directly utilizable by man for his food.

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Mussel culture augments food supplies to a great deal more efficiently than by farming most other food species. In the Indian waters two mussel species viz., the green mussel Perna viridis (L) and the brown mussel P. indica (Kuriakose) are known to occur. The biology and life history of the green mussel occurring along the Goa coast have been studied in some detail (Rao, et al, 1975 and 1976). Adequate information on these aspects is also available on Perna indica (Kuriakose, 1980). For mussel culture procurement of seed in adequate quantities is very essential. For farming at present the seed are being collected from the vicinities of the natural mussel beds. Mussel culture has come to stay, the interest being awakened by the initial success met with in the demonstration farms. Dependence on natural resources of seed with increase in demand in future is bound to be met with some difficulties. Further transport of the seed from distant collection grounds to farming sites will present problems apart from expense involved. The laboratory studies on green mussel have indicated the possibility of inducing both sexes to spawn, fertilizing the eggs and rearing the larvae to the seed or spat setting stage (Rao, 1976). These results are of much interest for establishing hatchery techniques of seed production under controlled conditions. The varied aspects of breeding biology, larval growth and habits and settlement of seed outlined here pertaining to P. viridis, are of fundamental importance in the scientific management of mussel farming.

Sexual Maturity of the Gonads and Spawning

The ripe gonad follicles of the mussels surround the visceral organs and enter the mantle wall. In female they are orange red and in male light cream yellow. In P. viridis

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sexual maturity is attained in all individuals at a length of 25 mm when they have completed 3 months of life after settlement as spat, but some with ripe gonads even at a much smaller size of 15 mm in length have been observed to spawn in the laboratory aquaria. Taking the species as a whole, there is breeding round the year with two spawning peaks. A difference has been noted in the spawning periodicity of the older mussels above the marketable size of about 60 mm in length and in the younger ones below that size. The spawning in the older ones commences from July and lasts till December with peak spawning in September-November which is followed by abundant spat setting in October-November. In the younger ones the spawning is from January to April with its peak in about February-March but this is not followed by an appreciable settlement of spat. During the breeding season mussels collected a few days before or after the full-moon days and kept in the laboratory aquaria spawned immediately but how far this is indicative of a lunar periodicity is to be ascertained by further observations. In the act of spawning the male discharges the milt through the exhalent siphon in a steady, visible, whitish streams which soon diffuses into the surrounding water turning it cloudy. In the case of the female, the eggs which are orange yellow and liberated in a streams, settle down at the bottom in the vicinity of the mussel discharging them.

That like most other bivalves mussels can be induced to spawn is known from the observations of Field (1922), Iwata (1950, 195[illegible]), Loosanoff and Davis (1963) and Ino (1973). When mussels are vigorously shaken up in water and allowed to remain undisturbed for a time, they would liberate spawn; if an electric shock stimulation at 20 volts for 5 seconds is administered the mussels would react in the same manner;

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and thermal shock given by keeping the mussels at a higher water temperature than that of the environment from which they are taken mussels would respond in releasing the eggs. Some chemical solutions as NH_4 OH, KCl etc. in weak dilutions would also produce the same result when they are injected in minute quantities into the tissues of the mussels. In the European mussel Mytilus edulis pricking the posterior adductor muscle initiates spawning. The centre of nervous control for spawning reaction is considered to be located in the posterior adductor muscle. It is also known that when ripe reproductive elements of a mussel of one sex are placed in water, spawning reaction is initiated in mussels of the opposite sex, particularly when this is done along with the thermal shock treatment. With the exception of electrical stimulation the above cited methods have been tried by the present writer in inducing P. viridis to spawn. No particular method gave unfailing results in all the experiments. However, the thermal shock treatment of increasing the water temperature in which the mussels were kept to about 5°C above the prevailing water temperature (not exceeding 35°C in the experiments) gave satisfactory results during the breeding season. The males reacted very favourably in about 30 minutes in most cases, (75 % cases) but in only about 20% of the experiments the females responded. The eggs discharged were in very good condition and they were readily fertilized with sperm liberated by the males in the same experiments.

Structure of the Egg, Fertilization, Early Development upto Trochophore

The spawned out egg, which is orange red in colouration and enclosed in a thin vitelline membrane has granular yolk in its cytoplasm surrounding a centrally placed nucleus and measures about 50 um in diameter. /

/Fertilization is

external when ova and spermatazoa are shed into the waters in the natural environment. For tracing developmental stages the spawned out eggs were mixed with milt in the finger bowls and the developmental processes were followed by microscopic examination. A large number of spermatazoa swarm round the egg and one succeeds in fertilizing the egg. The first polar body is given off 20 minutes after fertilization followed by the second polar body about 10 minutes after. Simultaneously with the formation of the second polar body at the vegetative pole of the egg a hyalene lobe like protrusion the 1st polar lobe appears. It may be noted that the formation of the polar lobes is a characteristic feature in the segmentation of the eggs of Mytilus and a few other bivalve species (Reverberi, 1971). The egg undergoes cleavage dividing into 2 cells viz., the AB and CD cells. Along with the polar lobe at this stage a three lobed (trefoil) appearance is presented. The first polar lobe is now drawn into the CD cell with the result that this cell is larger than the AB cell. Before the second cleavage starts, the second polar lobe appears at the vegetative pole of the CD cell. The second cleavage results in four cells A, B, C and D soon after which the second polar lobe gets absorbed into the D cell. The third cleavage is 'spiral' and 'dexiotropic' which divides A, B and C cells equally into two halves each and the D cell into one small cell and one large cell. Further cleavages follow soon, the smaller cells spreading over the larger cells, giving rise to blastula stage which develops cilia and begins to rotate. Gastrulation takes place by epiboly the blastopore appearing first at the vegetative pole but subsequently shifting ventral wards. The embryo now undergoes a little elongation, broad at the apex and somewhat narrow posteriorly, passing thus to the next stage the trochophore which is reached in 6 to 8 hours after the fertilization of the egg and measures about 58 um on its long axis.

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It has an apical tuft of a few larger cilia, an archenteric space within and a stomodeal pit where the blastophore has closed i.e. ventralwards. Mouth and anus are absent and the late trochophore stage has dorsally a shell gland developed (Figs. 1-9).

Early and Late Veliger Stages

The velum with larger and powerfully vibratile cilia and the first larval shell or prodissoconch I are simultaneously formed after the trochophore stage. The larval shell is D-shaped and the two valves of the shell are united at the hinge which is straight. Hence the larva is said to be at the straight-hinge stage which is reached in about 18 hours after fertilization. It has been observed to measure 62 um at hinge. The well developed velum which is the only organ for locomotion has in its middle one or two slender long cilia, of the apical tuft of cilia of the trochophore. It has no mouth, oesophagus or intestine and anus. The archenteric space of the trochophore persists. This first stage veliger is apparently incapable of ingesting food (Fig. 10). In the next stage the larval shell grows a little bigger and the retractor muscles of the velum are clearly seen (Fig. 11).

The larval shell viz. the prodissoconch I grows as a result of deposition fresh shell material secreted by the mantle. This fresh deposition shows clear concentric lines of growth. The growing shell is now in prodissoconch II stage and the larva is often termed veliconcha (Bayne, 1976).

Between the third and the nineth day of development most of the larval structures gradually make their appearance. At first the alimentary tract with the mouth,

oesophagus, stomach with the associated digestive gland, a coiled or looped intestine followed by rectum and anus are formed; the anterior adductor muscle precedes the posterior adductor muscle; the statocyst and the rudiments of labial palps, foot and gills are also recognisable. (Figs. 12 and 13). The hinge is still straight.

By fourteenth to sixteenth day after fertilization the larva has grown to 225 - 278 um in length, developing a distinct umbo on the hinge. Hence the larva is said to be in the umbonal stage. In addition to the structures already mentioned a dark pigmented eye spot has appeared. Labial palps, the gill filaments and the foot have grown larger than in the earlier stages. The shell turns from yellowish to deep brown hue at the hinge. The velum continues to be the chief locomotor organ.

The Pediveliger and Spat

By eighteenth day some of the larvae have grown to 300 um in length; the shell is now a little oblique and the velum is still large and used for swimming most of the time near to the bottom of the culture bowl. The finger-shaped foot is often protruded and used for creeping. The pediveliger as it is now called fixes itself to substratum by byssus formation from the secretion of the pedal glands of the foot and under goes metamorphosis.

The changes that take place in metamorphosis are absorption of the velum, disappearance of the eye spot by cytolysis, elaboration of the labial palps and gills, a further enlargement of the posterior adductor muscle, and a gradual reduction of the anterior adductor muscle.

There is a marked oblique growth of the shell after the setting of the spat with the result that the umbo is seen at the anterior extremity of the shell.

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It is of some interest to note that there is no uniform development of the larvae resulting from the same batch of eggs spawned by a female. While some have far advanced in development upto eyed veliger stage others have been noted to be still in the late straight hinge stage. This disparity in growth was not due to lack of or insufficiency of food as the larvae were fed on a plentiful supply of algal cultures.

Duration of Larval Life

In the laboratory culture of the larvae, the pediveliger stage was first observed on the 16th day and spat settlement on the 19th day after fertilization. In the natural environment the duration of larval life may be shorter by a few days.

It has also been observed that after the pediveliger stage is reached settlement of spat has been delayed for prolonged periods. In the laboratory cultures most of the pediveligers continued to remain active without settlement for a maximum period of 56 days (Rao et al, 1976). The ability to delay settlement perhaps helps seeking favourable substrata, especially when the larvae are drifted by currents to distant environments.

Larval Nutrition

In rearing the bivalve larvae, algal cultures of a large number of species are widely used (Loosanoff and Davis, 1963). The algal species selected for the purpose should be small enough to be ingested, nutritious and readily acceptable to the larvae. Motile or floating species are generally preferred to non motile ones as the latter sink to the bottom of the culture vessels and not easily available to the free swimming larvae. In rearing the

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larvae of P. viridis cultures of Chlorella, Tetraselmis gracilis, T. chui and Synechocystis were used. The three latter species grew fast in the subcultures. The mussel larvae commenced feeding only from the third day after the fertilization of the egg by which time the alimentary tract was clearly formed. When Synechocystis alone was used, the larvae remained stunted. When a mixture of Synechocystis, Tetraselmis gracilis, T. chui and Chlorella were used, growth rate was favourable. Species like Isochrysis galbana and Monochrysis lutheri which are known to promote very good growth in bivalve /in general were /larvae not available for experiments.

Growth, Life Span and Maximum Size

Paul (1942), Ranade et al (1973) and Rao et al (1975) have furnished information on the growth rates of P. viridis. Paul's observations show that a maximum size of 14.5, 19.0, 55.5 and 93.0 mm in length was attained by the green mussel at Madras harbour in 30,84, 167 and 321 days. Ranade et al observed an average growth of 7.5 mm a month during October to May in spat set on Ratnagiri coast. A study by Rao et al (loc. cit) by length frequency distribution of mussels along the Goa coast shows modal size of 96 mm at the end of 1st year, 132 mm at the end of /and 2nd year/ 156 mm in the 3rd year, the average annual rates of increase being 96 mm, 36 mm and 24 mm at average monthly rates of 8, 3 and 2 mm respectively. It was also observed that in seed set fresh on floating buoys at Vengurla Bay the modal shifts indicated an average monthly growth of 8-8.8 mm during January to April in 1973 and a little less during October to March (1973-1974) being 6.0 mm. The maximum size observed in each month was much higher as

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shown in the table below:

Month	Age (months)	Modal size (monthly average) mm	Maximum (Monthly average) mm
January	3.5	30 (8.56)	34.5 (9.84)
February	4.5	39 (8.66)	42.0 (9.2)
March	5.5	45 (8.66)	56.5 (10.2)
April	6.25	54 (8.8)	63.0 (10.8)

It is seen from the table that a certain proportion of individuals attain a maximum size of 60 mm in about 6 months after initial settling.

The maximum size of the mussel along the Goa coast observed was 145 mm in length weighing 72 gm (after preservation in 5% formalin). The maximum size of specimen kept in Singapore National Museum is reported to be 170 mm in length (Kow et al, 1973). Deduced from the size frequency studies carried out here, this length is expected to be attained in the fourth year of its life. The life span does not seem to be beyond 4 years.

Some ecological considerations and conclusion

Mussels are littoral in their distribution, densely set over rocky coasts. The setting of spat is immense after the monsoon months commencing from about November and extending to April along the Goan coast. The regions where the spat set are from about 1 m high at LWST to varying depths depending on the availability of hard substrata. In the shallow waters mussels become scarce by April as they are fished and removed by local people rather indiscriminately. In the deeper waters they thrive all round the year as their removal is met with some

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difficulty as only a few fishers who know diving can approach the beds. The deeper waters in the intertidal region seem to favour growth better than in the very shallow waters where partially or wholly the mussels are exposed at low tides. The main source of collection of spat for culture purposes are vicinities of the natural beds and the pattern of depthwise setting of the spat needs an intensive study of the production areas.

In the laboratory rearing of mussel larvae it has been found that although pediveliger stage is reached in large number of larvae, the setting of spat has been observed to be poor as it is not known the kind of culch that is favoured most for settlement. The elucidation of this helps hatchery techniques.

The adult mussels appear to tolerate variations in water salinities of the environment a great deal more than the larvae as shown by Kow et. al. (1973)(10 to 35‰ by the adults and 26 to 29‰ by the larvae). Observations along the Goan coasts have shown total absence of larvae in July - August at stations where salinities were low (6.8 to 13.99‰) although these months were within the breeding period. The occurrence of greater densities of larvae have been found to coincide with periods when the salinities were high. The choice of culture sites and collection sites of spat should be in such localities where fairly high salinities prevail for most part of the year. Information on the nutritional requirements of the growing mussels and fouling organisms associated with mussel settlements is still inadequate and these aspects need intensive studies.

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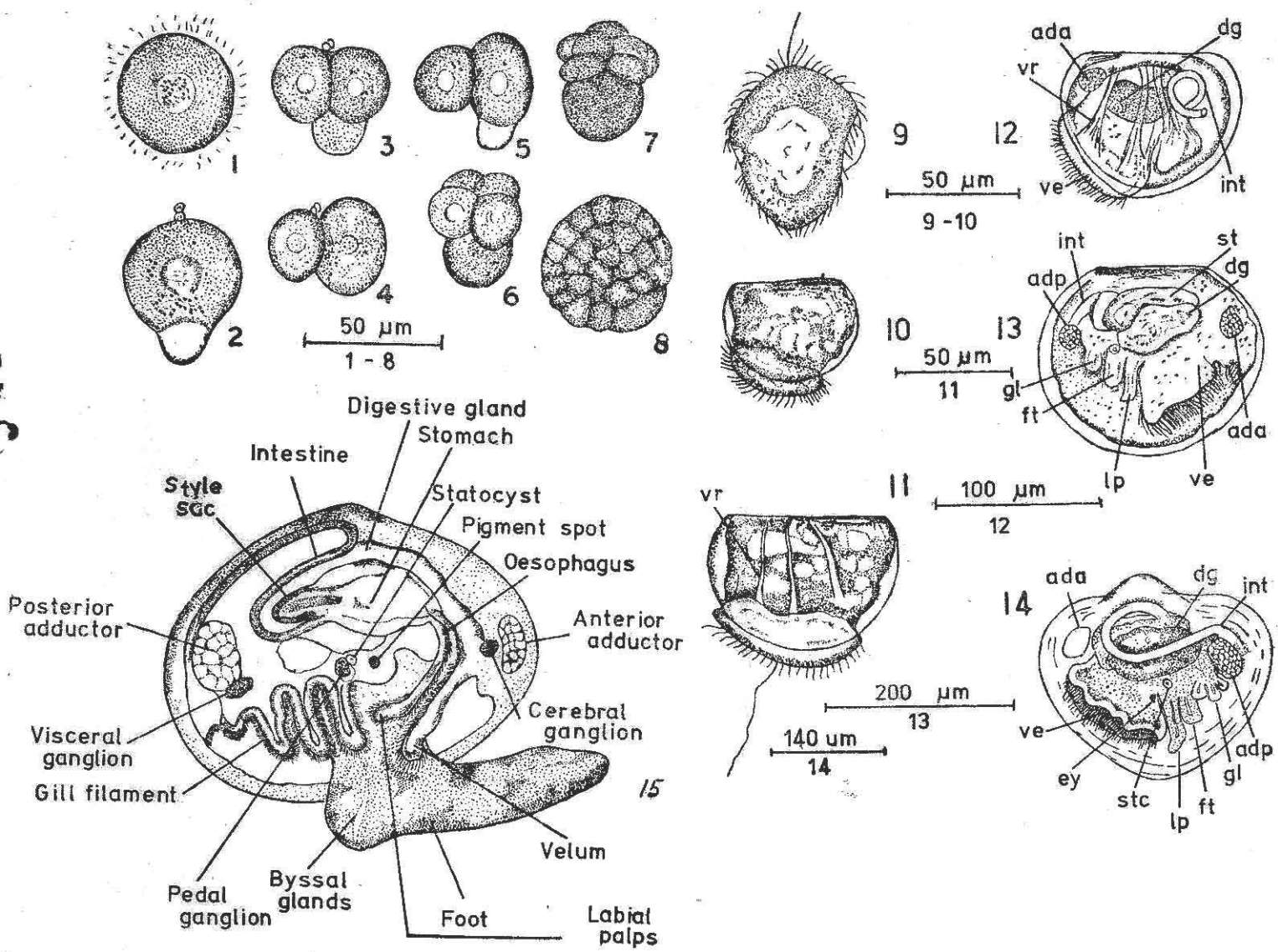

Life-History stages of *Perna viridis* (L): 1. Spawned out egg being surrounded by spermatozoa, 2. Fertilized egg with the 1st and 2nd polar bodies extruded out, 3. Trefoil stage after 1st cleavage with AB and CD cells and the 1st polar lobe, 4. Absorption of the 1st polar lobe into CD cell, 5. Appearance of 2nd polar lobe from CD cell before the 2nd cleavage appears, 6. AB and CD cells formed as a result of 2nd cleavage, also 2nd polar lobe is prominently seen, 7. Third cleavage divides the A, B, and C cells equally into D cell 2nd polar lobe enters and therefore it divides, 8. Smaller cells spread over larger cells forming blastula, 9. The trochophore stage, 10. Straight-hinge stage, D–larva or prodissoconch - 1st stage veliger, 11. Straight-hinge stage veliger developing velar retractors, 12. Prodissoconch – 2nd stage veliconch early stage with digestive gland, stomach and other parts of alimentary tract-Anterior adductor formed, 13. Prodissoconch stage further advanced in development, posterior adductor, statocyst, rudiments of labial palps, foot and gill seen, 14. Fully formed eyed veliger larva, and 15. Diagramatic representation of plantigrade larva of *Mytilus*.

Source : Rao *et al.*, 1976.
Figs. 1 - 14. *Indian J. Marine Sci.*, **5** : 113-116.
Fig. 15. Bayne, 1976.

Abbrevations : *ada* - Anterior adductor muscle; *adp* - Posterior adductor muscle; *dg* - digestive gland; *ey*- Eye-spot; *ft* - foot; *gl* - gill; *int* - intestine; *lp* - labial palp; *st* - stomach; *stc* - statocyst; *ve* - velum; and *vr* - velar retractors.

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CENTRE OF ADVANCED STUDIES IN MARICULTURE
WORKSHOP ON MUSSEL FARMING
MADRAS 25-27 SEPTEMBER 1980

TECHNICAL SESSION II	BIOLOGY, PHYSIOLOGY, AND GENETICS OF MUSSELS	CMFRI-CAS/MF/80/BP-7

SOME ASPECTS OF ENVIRONMENTAL PHYSIOLOGY OF RAFT GROWN MUSSELS

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A B S T R A C T

Mussels (Perna viridis L) from marine intertidal region, when transplanted and grown under constant submergence in estuarine environment (on a floating raft) display a wide array of physiological adaptions in osmoregulation, growth and annual reproduction cycle.

By employing sequential multiregression technique, the interaction of environmental abiotic factors influencing growth, both linear and in mass, has been assessed, and the dominant role of salinity established. Importance of the abundance of food for growth progression has been evaluated. Allometric growth in relation to the interaction of abiotic and biotic parameters is estimated.

Development of a physiological mechanism for compensating the water balance in the body to counteract the wide temporal variations in salinity is reported. Synchronization of annual reproduction cycle in tune with exogenous and endogenous variables and under different environmental

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and metabolic stresses is discussed. Behavioural, physiological and biochemical adaptations of raft grown mussels are highlighted.

INTRODUCTION

Mussels which occur in intertidal to subtidal regions of marine and estuarine environments of northern as well as the southern hemisphere have been extensively studied for ecological, Physiological and economic aspects. (Bayne 1976; Korringa 1977). However, no information is available about the environmental physiology of raft grown mussels and therefore, it was felt desirable to investigate the changes due to the interaction between the exogenous and endogenous factors, which the green mussel (Perna viridis L.) from a marine intertidal habitat has to undergo when transplanted and grown under constant submergence in an estuarine environment.

The environmental characteristics, growth rate and cultivation aspects of mussels in marine and estuarine environments of Goa as reported earlier (Qasim, Parulekar, Harkantra, Ansari and Nair 1977; Parulekar, Ansari, Harkantra and Nair 1978) has clearly indicated the high magnitude of temporal variation in environmental factors. Of particular significance is the observed wide fluctuations in salinity; high productivity, fast growth and prolonged spawning. In the light of these observations attempts are made here to analyse how best the mussel from a marine intertidal niche, acclimatizes, grows and propagates in a dynamic and demanding estuarine environment.

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OBSERVATIONS AND DISCUSSION

Growth: Growth as a response to the integrated activity of an organism as a whole is a sensitive parameter, reflecting on the suitability of environment (Warren 1971). It depends on the metabolic state of the animal, the energy expended in maintenance and behaviour and the quality and quantity of food consumed, all these are the functions of the environment. Growth in mussels as defined by Seed (1976) is not simply an increase in linear dimensions or mass (weight or volume) but also includes tissue formation and related activities that precede and follow the actual change in linear dimensions or in body size and hence the progressive changes either in length, weight and/or volume may be the most appropriate parameter for interpreting the growth.

Data on the influence of environmental abiotic factors on the growth is shown in Figrure 1. Organisms in an open environment as in the present study are not exposed to a single environmental factor at a time and the interaction of two or more abiotic factors, nearing "tolerance limit" (Shelford 1913) and attainment of "Steady State" (Kinne 1964) or "biokenetic zone" (Vernberg and Vernberg 1978) generally produces a more drastic effect on animal than would any single factor. One of the most frequently used method for quantifying the growth in relation to the interaction of more than one abiotic factor is the sequential multiregression analysis.

The method involves the measure of relationship of a given morphometric character (dependent variable) in terms of regulating environmental parameter (independent

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variable). As in the simple linear regression equation, it is presumed that the dependent variable has normal distribution with constant variable while the independent variable may possibly have irregular or arbitrary distribution.

Date on monthly length measurement was examined as a function of temperature (T), salinity (S), dissolved oxygen (O) and suspended particulate matter (SL). In other words:

$$L = f\ (T, S, O, SL)$$

The sequential multiregression of the relation between the dependent variable was first examined in respect of each independent variable, separately by the regression line:

$$L = b_1T + b_2S + b_3O + b_4SL + C$$

Where L is the predicted value of the dependent variable, b_1, b_2, b_3 and b_4 are coefficients of independent variable and C is the intercept. The values of b_1, b_2, b_3 and b_4 depend on the unit in which the original variables were measured and accordingly for the sake of uniformity, all the values were standardized by expressing each one as the deviation from the mean, measured in units of 1 standard deviation. The regression line then appears, as

$$L = b_1T + b_2S + b_3O + b_4SL$$

Where b_1, b_2, b_3, and b_4 are standard partial regression coefficients which give a measure of the contribution of each independent variable to the predicted value of the dependent variable. For testing the effectiveness of the multiple regression analysis, R^2 which is

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an estimate of the proportion of total variance on the dependent variable was calculated. The significance of R^2 was confirmed through variance ratio test by making use of F test. All the statistical analysis was undertaken on a TDC-316 computer.

The interrelationship between morphometric variables (Table 1) as assessed from the values of correlation coefficient indicate that length varies linearly with width, depth (height) and total weight. When all three variable are taken together, the multiple correlation coefficient does not show any further improvement (R^2 = 0.80).

TABLE 1

Simple correlation coefficient (r) between morphometric characters in raft grown Perna viridis L.

	L	W	D	TW
L	1.00	0.91	0.86	0.93
W		1.00	0.60	0.83
D			1.00	0.80
TW				1.00

The relation between length and abiotic environmental factors is shown in Table 2 and the regression equations along with the multiple correlation coefficients and F values based on variance ratio is presented in Table 3. Salinity becomes the dominant abiotic parameter in view of its higher frequency of occurrence in combina-

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tion of two and three variables at a time.

TABLE - 2

Simple correlation coefficient (r) between length and abiotic factors in raft grown Perna viridis L.

	L	T	S	DO	SL
L	1.00	-0.06	-0.25	-0.43	-0.22
T		1.00	0.59	0.08	0.21
S			1.00	0.24	0.34
DO				1.00	0.42
SL					1.00

TABLE - 3

Multiple regression equations for predicting length from the abiotic factors and multiple correlation coefficient along with F values based on variance ratio in raft grown Perna viridis.L

Regression Equation	Multiple correlation Coefficient R^2	F values based on variance ratio
L = -0.051 T + 0.112 S + 0.130 DO + 0.310 SL	0.21	1.08
L = -0.385 T - 0.009 S + 0.111 DO	0.18	1.29
L = -0.035 S + 0.238 DO+ 0.300 SL	0.22	1.57
L = -0.072 T + 0.185 DO+ 0.328 SL	0.20	1.39
L = -0.217 T + 0.570 S	0.39	5.70*
L = -0.376 S + 0.141 DO	0.19	2.12
L = -0.079 DO+ 0.339 SL	0.16	1.75
L = -0.206 T + 0.203 DO	0.09	0.88
L = -0.148 S + 0.281 SL	0.12	1.30

* Significant at 5% level of significance

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The relatively low magnitude of the variance ratio indicate any or all of the following:

a) The variability in abiotic factors is rather very large;

b) There is hardly any true relationship between length/weight and abiotic factors;

c) Observations are inadequate to find the true relationship, and

d) Additional important variable is lacking in the analysis.

The R^2 is a measure of mathematical association between variables and not necessarily the measure of physical relationship. Among the abiotic factors only temperature and salinity shows a significant relationship. In view of this when several abiotic factors are taken at a time, interrelationship may bring the reduction in the value of R^2 and confuse the interpretation of the variance ratio . The large amount of variations are probably due to wide variations in abiotic factors.

The role of biotic factors especially, the food availability, in the growth of mussels is indisputable (Seed 1976). In Figure 2 are shown the variations in the distribution of phytoplankton and particulate organic carbon in relation to cumulative growth progression in length and weight. Nannoplankton dominate the phytoplankton abundance in the area of study (Pant et al 1977). The curves (Fig.2) clearly indicate that the growth progression of both the linear (length) and exponential (weight) parameters is to a great extent dependent on the food availability and the seasonal variations are mainly due to the quantitative abundance of the phytoplankton. The present data being mainly field-oriented, the effect of quality of food on the growth of mussels could not be

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assessed.

By using the simple allometric equation $Y = ax^b$ (where Y is some measure of a part; X is a measure of the whole body or another part and a and b are constants to be estimated by least square regression technique, the dependence of morphometric parameters in respect of growth progression subjected to environmental variations are attempted. The relative increase in length, width, depth (height), total weight, shell weight, wet meat weight and dry meat weight indicates (Fig. 3) that in terms of temporal variations in abiotic and biotic environmental parameter, the growth continues, unabated, in one or the other morphometric dimension.

Accordingly, exponential growth was observed (Table 4) in total weight, wet meat weight and dry meat weight in relation to length with either cubic or square relationship. Lubinsky (1958) while discussing the possible adaptive advantages that mussels may encounter particularly in relation to adverse environmental conditions in relation to the growth of different morphometric characteristics has indicated that irrespective of variations in abiotic or biotic factors either jointly or independently, the growth as an indication of metabolic rate progresses.

COMPENSATORY MECHANISM

Of all the environmental variables, the salinity because of its wide fluctuations and its relevance to osmoregulation in organisms is a single important factor in an estuarine environment (Newell 1976). Animals often become excitable when the salinity of the medium is

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TABLE 4

Regression equations describing the allometric growth in raft grown Perna viridis L.

Relationship(Y/X)	Regression equation	r^2	SE
Total Weight / Length	$Y = 0.000513 \times 2.5001$	0.9861	0.271
Total Weight / Width	$Y = 0.000822 \times 2.8756$	0.9826	0.289
Total Weight / Depth	$Y = 0.00563 \times 2.6710$	0.9964	0.247
Wet Meat Weight / Length	$Y = 0.000001 \times 3.6422$	0.9653	0.321
Dry Meat Weight / Length	$Y = 0.000109 \times 2.2609$	0.9019	0.298
Shell Weight / Length	$Y = 0.000320 \times 2.6810$	0.9312	0.279
Wet Meat Weight / Depth	$Y = 0.00419 \times 2.5081$	0.9946	0.186
Dry Meat Weight / Depth	$Y = 0.000924 \times 2.4324$	0.9852	0.214
Wet Meat Weight / Dry Meat Weight	$Y = 0.3017 \times 0.6524$	0.6561	0.462
Dry Meat Weight / Total Weight	$Y = 0.1036 \times 0.9135$	0.9115	0.318
Dry Meat Weight / Shell Weight	$Y = 0.2129 \times 0.8325$	0.8616	0.338
Shell Weight / Total Weight	$Y = 0.4478 \times 1.0696$	0.8704	0.215
Wet Meat Weight / Shell Weight	$Y = 1.1268 \times 0.8666$	0.9612	0.238
Depth / Length	$Y = 0.4184 \times 0.9298$	0.9890	0.296

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changed and consequently expend increased energy on physical activity aswell as on basal metabolic processes (Gross 1957). Longterm response to given ionic condition results in enzymeic induction producing optimal conditions for energy supply (Lange 1968) whereas for short-term changes the animal reacts by developing a compensatory response (Lockwood 1976).

In the transplanted mussels growing on raft in an estuary, a compensatory mechanism in respect of osmoregulatory behaviour was observed. As shown in Figure 4, the mussels develop an isosmotic internal medium to compensate for considerable lowering of salinity during the monsoon season (June - September). The compensation is achieved by the dilution of the body fluids, resulting in higher water content in the tissues. In the postmonsoon, (October - January) and premonsoon (February-May) season, appropriate compensatory mechanism is exercised (Fig. 4) to counteract increasing salt content in the environment.

ANNUAL REPRODUCTION CYCLE

A complex of physical variables is thought to influence the sequence and timing of reproduction in mussels (Giese 1967). Besides the regulatory influence of exgenous factors like temperature, salinity, etc. the annual cycle of reproduction has dependence on the seasonal changes in the biochemical composition of the tissues (Dare 1973), and therefore, it was felt necessary to analyse the data on seasonal changes in temperature, salinity and biochemical constituents in relation to maturation and spawning in raft grown mussels.

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As shown in Figure 5, in the transplanted mussels of mean size 7 - 8 mm, the gametogenesis commences in the first month (December). In the second month i.e. January (Fig. 5) more than 70% of the animals were in maturing stage. The mature gonads in small proportion (10%) were first observed in the third month (February) after transplant. The occurrence of mature/ripe gonads increased from 38% to 85% in the succeeding months of March to May. Spawning, as evidenced from the occurrence of ripe as well as spent gonads, commences in the III month i.e. February and becomes intensive in March-April before attaining the peak spawning in May i.e. in the VI month since transplant. The "resting phase" coincides with the heralding of monsoon rains in June. It is followed by the recurrence of immature gonads, in July; maturing in August and the spawning commencing in September, intensifying in October and November. Thus, the species exhibit a prolonged breeding behaviour with spawning peaks in the favourable seasons, before and after the monsoon.

Annual cycle of reproduction is colsely associated (Fig. 5) with the temporal variations in temperature and salinity. While proliferation of germinal epithelium, maturation of gametes and spawning maxima coincides with favourable condition of temperature, salinity and abundance of food material (Fig. 2) the resting phase coincides with the lowering of temperature, salinity (Fig. 5) and scarcity of food.

Similarly, the seasonal change in some of the biochemical constituents, are associated with the different phases of annual cycle of reproduction. According-

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ly, the protein and lipid content (Fig. 5) shows a decline coinciding with the maturation, spawning and phase of recovery during the resting stage of gonads. Second maxima of protein content in September (Fig. 5) can be attributed to the abundance of food material (Fig. 2). Carbohydrate content exhibit an inverse relationship with the lipid content and thus serves as an index of high glycogen metabolism during the period of extreme environmental stress in the monsoon season (Fig. 5).

The foregoing account of some aspects of environmental physiology of raft grown mussels can be considered as a case history, for assessing the physiological adaptations, an organism from marine intertidal regime acquires when transferred and made to thrive in an estuarine subtidal biotope. Not only does the organism, Perna viridis L. thrives under the changed environmental conditions, but establishes, in the most successful way. It attains higher growth rate, propagates in tune with the environment and maintains a better metabolic condition than in the marine environment (Qasim, Parulekar, Harkantra, Ansari and Nair 1977). Thus it adapts bahaviourally, physiologically and biochemically, not only to wide ranging external conditions but also responds appropriately to rapid and irregular variations of these conditions. As discussed by Lockwood (1976), the breadth and flexibility of response is not based on the development of any fundamental new process but rather on the evolutionary adaptation and modification for different processes already present in marine species. However, it must be

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recorded, here that the present set of data has further to be substantiated by experimental work especially on oxygen uptake, rate of grazing, energy conversion efficiencies etc. for getting an insight into the physiological ecology of raft grown mussel and the work in this direction is in progress.

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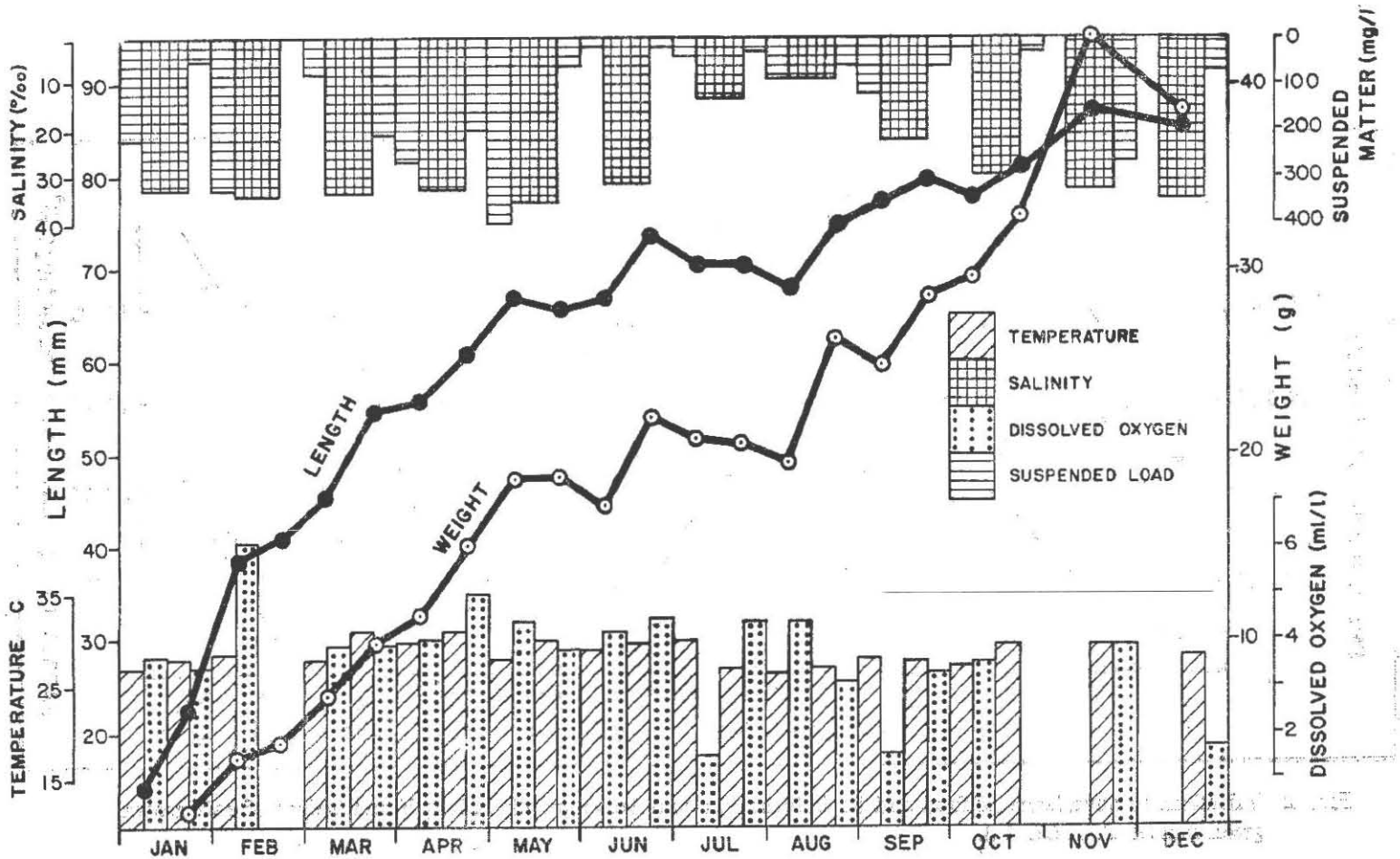

Fig. 1. Environmental factors and growth in raft grown green mussel (*P. viridis* L.).

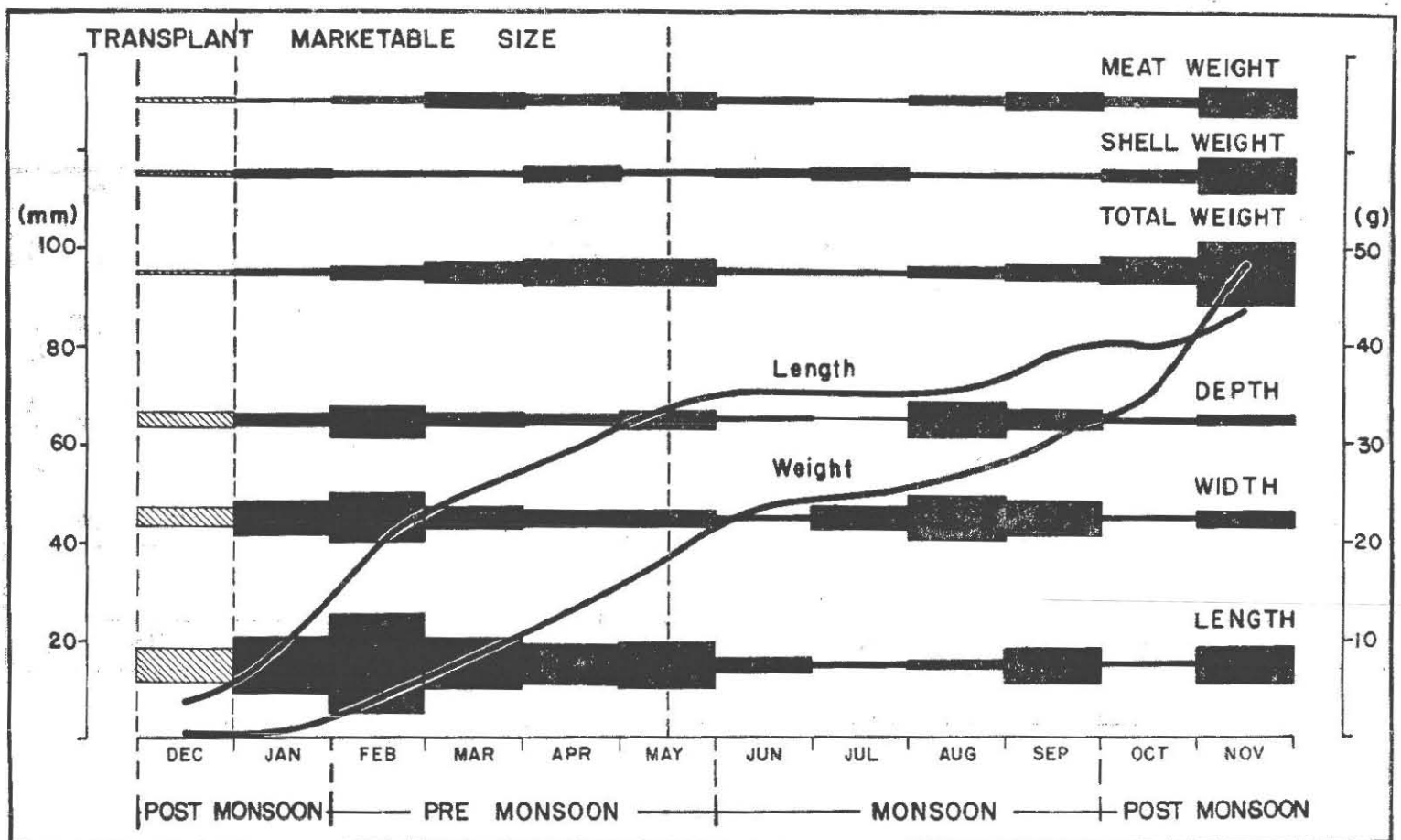

Fig. 3. Allometric growth in raft grown green mussel (*P. viridis* L.).

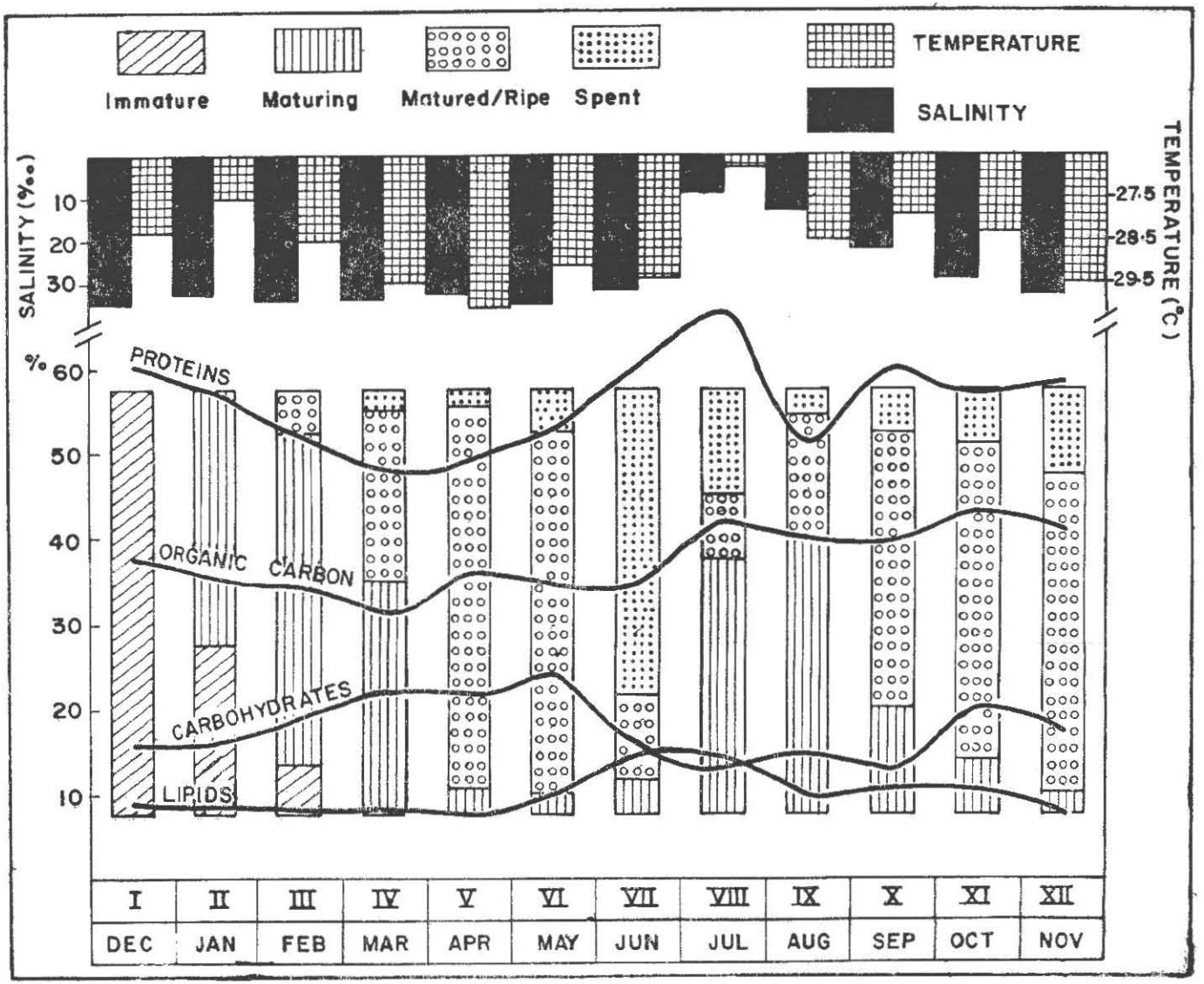

Fig. 5. Role of exogenous and endogenous factors in the growth of raft grown green mussel (*P. viridis* L.).

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TECHNICAL SESSION III MUSSEL CULTURE TECHNOLOGY : CMFRI-CAS/MF/80/BP -8

CRITERIA FOR SITE SELECTION FOR MUSSEL FARMS

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INTRODUCTION

In recent years considerable progress has been made in cultivating mussels in India. Mussel culture forms an important programme in the mariculture activities of countries like France, Spain, Italy, Netherlands and North America. Many countries in Asia like Singapore, Philippines, Thailand, Indonesia, etc., have also taken up mussel culture in recent years in view of its high production potential.

In India the mussel culture has been taken up in a number of places. The Central Marine Fisheries Research Institute has been carrying out culture of brown mussel, Perna indica at Vizhinjam and the green mussel, P. viridis at Calicut and Madras. Experimental work on mussel culture has been carried out in Goa by National Institute of Oceanography, Ratnagiri and Kakinada. A pilot project on mussel culture has been taken up by the Government of Kerala in Vizhinjam. This shows the wide interest that has been

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awakened for mussel culture in our country.

India has a coastline of about 6100 km and offers immense scope for mussel culture. Before a site is selected for mussel culture a detailed study about the topography of the place, environmental conditions like salinity, oxygen, temperature, rainfall, pollution, etc, should be carried out.

Let us first consider the different methods of mussel culture that are in vogue and the criteria applied for the site selection for farming by each method.

DIFFERENT METHODS OF CULTURE AND CRITERIA FOR SITE SELECTION

A perusal of the available literature shows that the following methods are generally adapted for mussel culture.

1) Mussel farming on sea beds.
2) Mussel farming on rows of poles.
3) Mussel farming on rafts.
4) Mussel farming on long lines.
5) Mussel farming on racks.

The success in farming by any one of the above methods depends upon many environmental factors and great care should be taken in choosing the site for farming. Let us take up the methods one by one and sea what are the criteria that should be applied in selecting the site.

On bed culture:

This type of mussel culture is widely practiced in Netherlands, England and West Germany. The farms are located from the low water level down to a depth of 5 or 6 meters.

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The bed should be of firm texture consisting of sand and little mud. Areas with shifting sands and strong tidal currents are not suited for this type of culture. Tidal mud flats where mussels would be exposed for many hours between tides should be avoided since growth will be poor in these areas.

The salinity fluctuations over the farm area should not be large. Sudden lowering of salinity below 20-25°/.. causes heavy mortality. Areas subject to influx of fresh-water are not suited for locating the farm.

The water over the farm area should be fairly clear and rich in phytoplankton. Large amount of silt in the water will choke the gills of growing mussels and interfere with their growth. Since wind exerts an influence on the amount of silt suspended in water, areas protected from strong winds should be chosen.

The area selected should be free from the discharge of industrial wastes and sewage to prevent pollution. It should also be free of predators like star fish and crab which cause damage to mussel beds.

Sea bed culture has not been tried in our country. Many shallow bays are available along our coast where this method of culture could be practiced. Suitable sheltered areas are available inside most of the estuaries along the east coast. They are in communication with the sea for 6 to 8 months and mussel parks could be set up after preparing the beds. Since this is an easy method of mussel culture without much capital investment, suitable areas could be selected for popularising mussel culture in our country. Shallow

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areas in Palk Bay and Gulf of Mannar could be utilised for this type of culture.

Pole Culture (Bouchot method of France)

This method is prevalent in France where mussels are grown on rows of long poles driven into soft mud of the tidal region. The ground should be gently sloping and tidal amplitude fairly high so that greater portion of the poles are exposed during low tide. The farm area should be selected with great care after testing the bottom for underlying obstructions. The lower 2 or 3 meter length of the pole should be driven into the substratum so that the poles could withstand the waves and current. Areas in the sea where there is a thin layer of sand over rocky substratum, as in Kovalam bay, are not suitable. Poles erected in such areas topple over when the sandy layer is eroded by current and waves.

Areas exhibiting wide fluctuations of temperature and salinity should be avoided. Sheltered areas should be preferred as heavy swells and waves uproot the poles if they are not firmly fixed. Areas in the sea prone to infestation of Teredo sp., Pholas sp. etc, should not be selected. In course of time the submerged portions of the poles are heavily riddled with Teredo and the poles break at the water level when waves and swells sweep across the farm area.

Suitable areas for pole culture are available in Kutch, Sunderbans and Andaman Islands where tidal fluctuations are high.

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Raft Culture:

Raft culture is carried out in Spain extensively and very high production has been obtained by this method. Large rafts are anchored in deep bays and the mussels are grown on ropes suspended from the raft. The substratum should be of soft mud so that the rafts could be securely anchored. Areas with rocky outcrops should be avoided since the anchors are likely to get fouled up. Moreover swells when they pass over submerged rocky outcrops increase in height and disturb the rafts.

For raft culture to be successful fairly calm waters are absolutely essential. If rough sea conditions prevail in the area selected for raft culture, the raft will be tossed up and down violently. The mussel ropes as a result, swing violently and there is a likelihood of mussels falling down from the rope due to ropes getting entangled with each other. At the time when seeded ropes are suspended from the raft, calm conditions are essential at least for a few days so that the mussels could attach themselves securely on the ropes. Waves seem to influence the time taken to form the byssal threads. If the substratum i.e. the rope is in continuous motion, the mussels do not secrete the byssal threads and fall to the bottom of the sea when the cotton netting enclosing them disintegrates.

Areas opposite to or slightly south of the bar of an estuary are not ideal to locate the rafts. During the rainy season these areas are subject to heavy influx of fresh water and sudden lowering of salinity. Freshwater moves over the more saline water as a fast current and due to the prevailing

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winds at that time is carried south wards. Heavy mortality of mussels in the top 0.5 - 1.0 meter of rope takes place due to sudden lowering of salinity.

Areas near submerged rocks abound with fishes belonging to the genus Caranx specicsus, Platax tiera, Scatophagus argus, etc, and they cause damage to the seeded ropes. Before the mussels have time to secrete the byssal threads for attachment, these fishes puncture the netting cloth used for seeding by constant nibbling and the seeds fall out. The fishes damage the cloth while feeding on the detritus which settle upon the cloth due to the filtering action of the mussels.

Another criteria which should be borne in mind is that the area selected for farming should be as near as possible to natural mussel beds. Since the whole culture operation at present mainly depend upon the mussel seeds that settle profusely on rocks, location of the site near natural beds will cut down the cost of transportation of the seeds.

Since fouling organisms like ascidians, sponges, etc., compete for space and food with mussels on the culture ropes, areas which abound with the above organisms should be avoided.

The area selected for farming mussels by raft should be free from pollution by sewage, pesticides, industrial wastes, discharge from nuclear power plants, oil spills and chemicals. While selecting the site it should be borne in mind that these pollutants are likely to be carried by ocean current over long distance.

To ensure high bacteriological purity the mussels should be cleaned and left in large tanks containing filtered

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pure sea water for about 24 - 48 hours. In order to cut down the cost of production the farm area should be located very near or in a place where these infrastructure facilities are available.

Generally the fishermen resent the presence of these rafts in their fishing area. Rafts in the inshore area are likely to hamper the shore-seine and drift net operations of the fishermen. It will be a problem to select a site which will not clash with the interests of the fishermen.

Suitable areas for raft culture could be found in the west coast of India and in Andaman Islands where there are numerous sheltered deep bays with calm conditions.

Long Line method:

In this method the mussel ropes are suspended from long ropes stretched between buoys anchored firmly on the sea bed. Floats are used at regular intervals along the rope to prevent it from sagging too much and touch the bottom. The long line method can be used in fairly deep waters. The area should be free from pollution and have rich phytoplankton/ to ensure rapid growth of mussels. /production

The long line method could be used in areas where the sea conditions are rough and rafts are difficult to maintain. The usefulness of this method is being evaluated at Kovalam now.

Rack cultivation:

In this method practiced in Yugoslavia, mussels are grown on racks which are kept submerged but well above sea bed. It is an ideal method for shallow creeks where low tidal current is present. This method has been successfully

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used in Tuticorin for growing edible oysters. The growing mussels in the racks are likely to be covered by dense silt. The rack requires periodic cleaning in order to remove not only the settled silt but also the predators that might have reached the rack. The wooden poles and racks are subject to attacks of Teredo and are likely to be destroyed quickly. Sheltered conditions are essential and polluted areas/avoided; Creeks with influx of freshwater/to be are not suitable.

GENERAL CONSIDERATIONS

Whatever method is adopted for mussel farming the success in farming depends to a large extent on the site selected. It may be stated that the site selected should be located in a sheltered area which is not subjected to extreme variations in temperature, salinity and oxygen. Areas subject to influx of freshwater should not be chosen for mussel culture since mussel cannot tolerate low salinity for long time.

Mussel culture in estuaries and backwater areas cannot be carried out throughout the year since for part of the year the bar/of most of the rivers remain closed. Moreover / month estuarine areas are subject to human interference and are polluted by industrial wastes and sewage. Heavy mortality is likely to occur to the mussels when the bar is closed and the water gets more polluted. In Mussels grown in estuaries there is a possibility of bacterial load going up and the product may not be good for human consumption.

Areas in open sea are generally free from pollution and are suitable for mussel farming. If the site is free

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from storm and cyclones and located in sheltered areas, it is ideal for mussel farming by raft method. The sea conditions play a vital role on the success of mussel farming. Calm conditions are essential not only for the safety of the raft but also for successful spat fall and attachment of seed on the ropes. Past experience at Kovalam shows that calm conditions are absolutely essential when seeded ropes are put on the raft. In fact the total production depends upon local weather conditions. In rough weather the mussels fail to produce byssal threads, fall down from the ropes and are lost for ever.

Another point which should be taken into consideration is that although suitable vast areas are available for mussel culture it may not be possible to carry out the culture operation in many of the areas. Suitable areas in the open sea overlap the area of fishing operations by local fishermen. Rafts cannot be located in fishing areas since its presence will interfere with the shore-seine and drift net operations. Steeped as they are in age old practice of capture fishery the fishermen, especially of Tamil Nadu, are very slow to appreciate new ideas. The idea of culturing marine animals is strange to them and lot of persuasion is required even to tolerate the presence of rafts in their fishing areas, leave along their active co-operation. The situation is bound to change in the course of time when they realise that mariculture is another rewarding method for improving their socio-economic conditions.

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CENTRE OF ADVANCED STUDIES IN MARICULTURE

WORKSHOP ON MUSSEL FARMING

MADRAS 25-27 SEPTEMBER 1980

TECHNICAL SESSION III MUSSEL CULTURE TECHNOLOGY | CMFRI-CAS/MF/80/BP-9

MUSSEL SEED COLLECTION AND PRODUCTION

S. MAHADEVAN

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PRESENT STATUS

All leading mussel farming countries in the world producing annually 330000 tons (weight in the shell) of mussels depend on natural seed resources to meet their requirement of seed, whether it is for bottom culture (Netherlands), bauchot culture (France), raft culture (Spain), rack culture (Italy) or submerged pole culture (Phillippines). Hatchery system of mass seed production, therefore, has not become necessary unlike in the culture of other edible molluscs like oysters, clams and abalones wherein suitable techniques are employed by the industry. While the above systems confer specific advantages like production of fast growing and disease resistant strains through cross breeding and immunisation, mussel culture industry goes on without any need for such developments, since none of the mussel farming countries has experienced shortage of natural seed supply so far. The mussel spats settle down and colonise the intertidal rocky areas as well as hard substrata of the subtidal zone.

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Myriads of seed thus available are easily collected by simple inexpensive methods like picking or scraping.

From table 1 below it may be noticed that in many countries spat collection by employing collectors, mainly synthetic ropes is also being done.

TABLE 1. MUSSEL SPAT COLLECTION METHODS EMPLOYED IN DIFFERENT COUNTRIES

Country	Seed collection methods
1. Australia	Spat collection by suspending ropes
2. France	Horizontally streching coco fibre ropes under sea water; erecting Pine-poles in shallow flats
3. Germany	Suspending ropes of different diameters
4. India	Natural beds; suspending frilled ropes (nylon and coir); employing roofing tiles; laying concrete blocks
5. Italy	Natural beds; employing artificial spat collectors.
6. Ireland	Spat transported from Scotland
7. Netherlands	Natural beds
8. Newzealand	Suspending 'Sisal' ropes; twigs.
9. Norway	Suspending 'Polypropylene' ropes
10. Philippines Thailand	Deploying bamboo structures erected over shallow flats
11. Scotland	Suspending 'Coir' ropes
12. Spain	Natural grounds; suspending synthetic fibre ropes from mussel Parks.
13. Venezuela	Natural grounds; suspending synthetic fibre ropes from mussel Parks.

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GENERAL CONSIDERATIONS

Mussels which settle down on natural beds often do not grow there satisfactorily from a variety of causes Prolonged exposure of such intertidal beds during low water neap tide destroys the seed stock. Silting of such areas due to sand and mud thrown in by wave action engulfing and destroying colonies of mussel spat season after season is another adverse factor. With increasing industrialisation of coastal belts the danger of coastal pollution upsets the ecosystem thus creating problems for seed settlement and survival. This problem is particularly relevant to advanced countries where the coast line is restricted. In India this problem has not become acute so far. The above considerations would naturally imply that in the distant future hatchery seed production may have to be restored to for an assured seed supply. Apart from reports of efforts in mass production of mussel spat in Polynesia (Aquacop, 1980) and laboratory experiments summarised by Bayne (1976) there appears to be no other attempts for controlled mussel seed production. This gap in our knowledge needs to be adequately filled.

Another aspect demanding attention is the development of standardised technique for the transport of mussel seed from areas of availability to distant farm sites. For a country like India with a long coast line and two distinct monsoon periods for the west and east coast the above technique may become invaluable especially because of the paucity of green mussel resources along the east coast. There is an element of uncertainty of seed availability

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along east coast since the breeding stock is thin and restricted to certain strips. The spawning season of east coast mussel happens to be just 3 months prior to the outbreak of north east monsoon and the seeded stock may be destroyed by the active monsoon winds and choppy sea. The seed settlement in west coast is in October-November when mussels of size 25-30 mm can be collected and safely transported to farming sites in east coast. This would enable seeding in December-January period which happens to coincide with the abatement of North east monsoon. The rafts can also be safely floated and mussels grown to market size in a period of 4-5 months. The abundant, unutilized seed resources of west coast area from Cochin-Malabar-South Kanara zone can be purposefully utilized. In the intensive development programme of mussel culture management of seed resources is one of the priority areas for attention.

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TECHNICAL SESSION III MUSSEL CULTURE TECHNOLOGY | CMFRI-CAS/MF/80/BP-10

SYSTEM DESIGN FOR MUSSEL CULTURE

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INTRODUCTION

Mussel culture has been proved as one of the feasible programmes for large-scale production of cheap protein food in many of the European countries having considerable potential for production to the tune of 600 tonnes/hectare as is reported from Spain. It also opens new avenues for generating employment possibilities for unemployed personnel and also for fishermen to take up as a subsidiary source of income in addition to their normal fishing activities, which may help in improving their social conditions also.

The progress in the line of work is recent in India and the Central Marine Fisheries Research Institute has initiated the work in 1971 at Vizhinjam on culturing brown mussels Perna indica and subsequently on green mussels P. viridis at Calicut and Madras. The results produced by National Institute of Oceanography (Qasim et al 1977) and the Konkan Krishi Vidya Peeth, Ratnagiri are also encouraging. The Central Marine Fisheries Research Institute has already sponsored a pilot project, which has been taken up at Vizhinjam by the Department of Fisheries, Government of Kerala. It is quite appropriate at this context to have a system design for mussel culture for formulating large-scale programmes to be taken up whereever it is possible in the Indian coast or elsewhere. The

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information given in this paper is only a broad outline of the system developed in many of the advanced countries and the production patential of mussel culture and the system suitable for our condition which could be considered with marginal variations at different places depending upon the cost of material and physical as well as biological features of the environment while formulating projects.

DIFFERENT ECOSYSTEMS AND THE SUITABLE METHODOLOGY

India is having an extensive coastline bordering the different maritime states with rocky as well as sandy shallow areas, intertidal flats, lagoons and bays with fully marine conditions where mussel culture is possible. As mussels prefer to have saline conditions ranging 25 to 36‰, suitable areas are to be identified at the above ecological regions before taking up large-scale programmes. As such rope culture using floating rafts and by using longlines, stake culture, tray culture and relaying or spreading mussels in favourable shallow areas are the methods developed and suitable farming procedures are to be adopted for the respective areas. Normally culture programme not only helps in increased production but also helps in conserving enormous quantities of spats or seed-mussel-settling on the inter-tidal areas which in course of time perish due to continued exposure. It is worthwhile to mention the different methods suitable for the different ecological conditions in this connection.

CULTIVATION IN DEEPER AREAS

Ropes suspended from fixed frames, floating raft method or suspending ropes from long-lines are the methods adopted in various countries whereever the depth is more than five metres.

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The method of suspending ropes from fixed frame is common in southern France, Spain, Yugoslavia and Italy(Mason, 1972). However, this can be possible only along the border areas of the lakes in shallow regions and is a flourishing industry in Naples, Italy.

An improvement on this method is made by suspending ropes from floating frame work and this has been impressively developed in Spain. These structures are known as floating parks and are anchored in the Galician rias which may extend up to 25 km length-wise and 3 to 12 km width-wise and having a maximum depth of 60 m. Earlier these rafts are constructed on old hulls of boats and at present four or more floats coated with cement or fibre glass are used for floation. If the float is single it is 12 x 4 x 2 m and if four floats are used it is 2.5 x 2.5 x 1.9 m. (Andreu, 1968a ;Ryther,1968). A frame-work of Eucalyptus beams is fixed over these floats and is supported by iron stays from the end of beams to the masts fixed on the floats. Generally a typical raft supports 500 to 600 ropes and is of $20m^2$ area with a working platform and shelter for workers. There are even larger rafts supporting even 1500 ropes (Andreu,1968 b) and the estimated cost in 1968 for a typical raft is about £2200-2800 (Wiborg and Bohle, 1968). Anchoring is done by chain, 32-36 mm thickness and 6 to 7 times that of the depth and using huge cement blocks as anchors. The annual mussel production is estimated at 50 tonnes per such raft (Andreu,1968 c).

At vizhinjam, rafts of 5m x 5m are constructed using 36 bamboos and using nylon rope of 4 mm ~~thickness to tie~~ them into a frame-work. Each raft is floated using 4-6 empty oil barrels (200 litre) and in few cases a coating of fibre glass is given. The raft is anchored using 12 mm nylon rope at four corners and using granite stones with iron clamps as anchors. This is found to be the cheapest method for calm areas. For rough conditions additional teak poles are used for the frame along with iron chain and iron anchors for anchoring ~~in the open~~ sea as is done at Calicut. Experiment is in progress for a design of

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submerged raft at Kovalam, Madras. A raft of the above dimension can support 50 ropes for culture. The annual production is estimated at 3 to 4 tonnes if six metre seeded ropes are suspended. The production potential and rate of growth of brown mussel Perna indica at Vizhinjam bay is presented in table I and fig. I for further details.

(1) Open Sea

If wave action is prevailing heavy investment is required for keeping floating structures, at least an average length of 5-6 metre is to be retained for the seeded portion of the rope for getting good returns. The production per raft and per hectare will depend upon the number of ropes suspended in the area as well as the length of the seeded portion of each ropes and invariably whenever heavy investment is required for the construction of the raft as well as for anchoring them in the sea the above factor is to be given special consideration. It is already observed that a reliable average production of 10 kg/metre of rope length could be obtained per metre of seeded rope at Vizhinjam (Achary and Thangavelu, 1980) and the production cost and returns can be computed as given elsewhere in this paper. If rafts cannot be permanently retained in the sea due to rough weather, an additional expenditure for the seasonal operation also is to be anticipated.

(2) Bays and Lagoons.

Raft culture is most successful in bays and lagoons where depth is more than 5 metres and having a rich production of phytoplankton. Areas protected by reefs and or islands also can be included under this type of ecosystem but the production can be at a higher rate because of the frequent replacement of water by tidal action.

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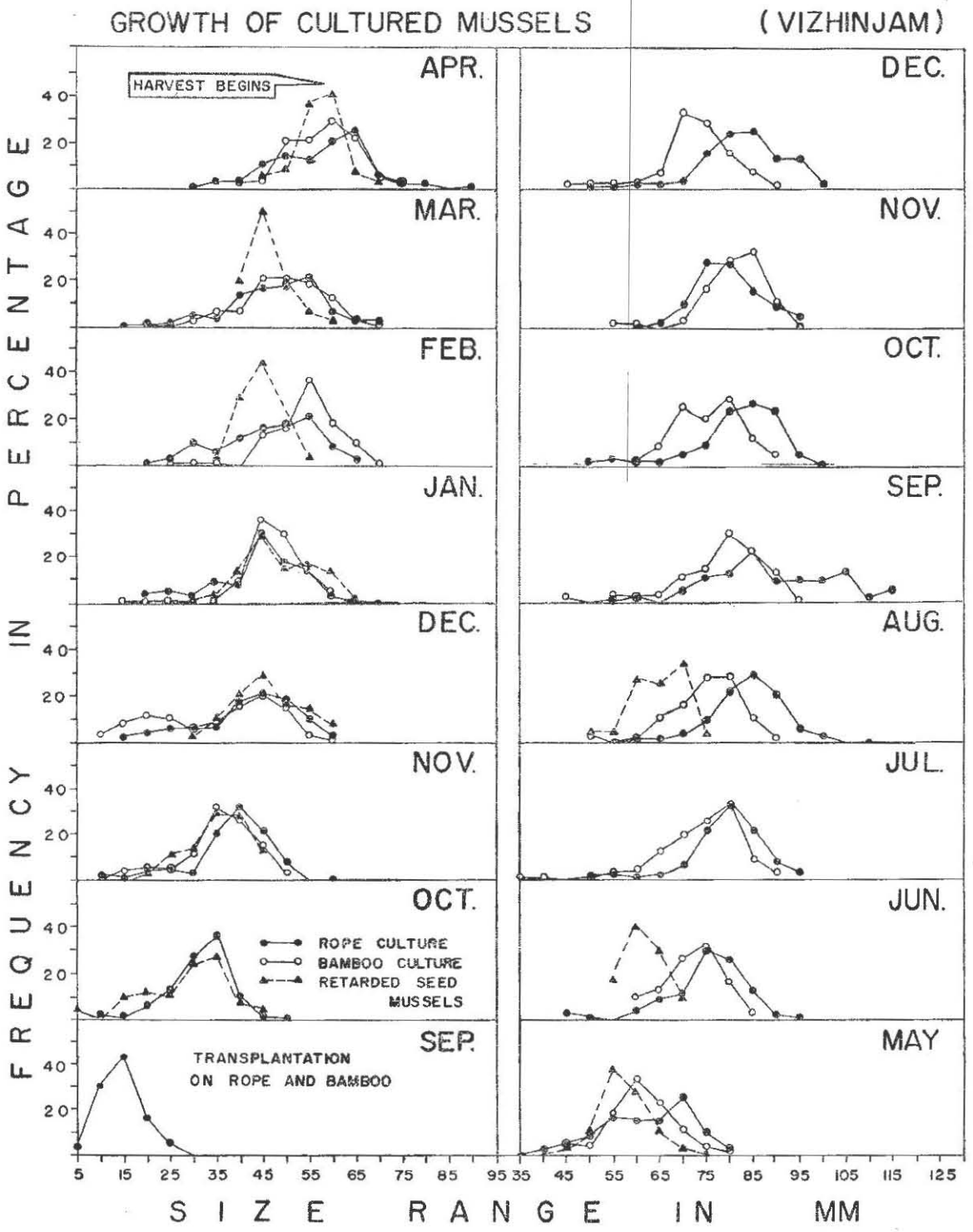
GROWTH OF CULTURED MUSSELS (VIZHINJAM)
HARVEST BEGINS
APR.
MAR.
FEB.
JAN.
DEC.
NOV.
OCT.
SEP.
DEC.
NOV.
OCT.
SEP.
AUG.
JUL.
JUN.
MAY
ROPE CULTURE
BAMBOO CULTURE
RETARDED SEED MUSSELS
TRANSPLANTATION ON ROPE AND BAMBOO
FREQUENCY IN PERCENTAGE
SIZE RANGE IN MM

CULTIVATION IN SHALLOW WATERS

The principles involved is to give a favourable environment for the mussels to grow at a faster rate compared with the growth at the normal mussel beds by either spreading them on very shallow areas having hard substratum or if the depth is at least 2 m. during the low tide; culturing them on stakes utilizing the three dimensional culture procedure. Since the procedure is too simple these methods have been evolved in U.K and France respectively much earlier to the introduction of hanging culture in Spain.

(1) Stake culture.

This method is used since the 13th century on the western coast of France and even now is the principal method in France, (Audouin, 1954) and is known as 'bouchot' system. Pine stakes are planted as collector bouchots off from the shore. Poles of 4-5 m length protruding 1.6-2 m are planted 35 cm. apart on the tidal flats. From these mussel spats of 20 mm size are collected and transferred to rearing bouchots planted at a distance of 75 cm and horrizontally interwoven with branches of willow or chestnut tree. Seed mussels are then transferred to them in bags of fine mesh netting and after disintegration of the netting, mussels attach themselves to the rearing bouchots (Mason, 1972). The total length of bouchots exceeds 600 km on the mid western coast of France (Lambert, 1939). Young (1969) reports about 900 km of them. Since natural spat fall is not available on the northern coast of Brittany they are collected by suspending loosely woven ropes at the natural beds at LaRochelle and are transferred to Brittany and wrapped spirally around the poles (Ryther, 1968). At an average a family maintains 10,000 to 25,000 poles in France (Mason, Loc cit) and the total mussel production in France amounts to 30,000 tonnes (FAO, 1970).

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Obusen and Urbano (1968) have described the methods of Philippines. By this the stake method is used in two ways. In areas of about 2.5 m depth during low tide, bamboos are staked at a distance of one metre in two rows and they are interconnected at the top by horrizontal bamboos. The second method which is known as 'wigwam' is by planting 8 radial bamboos just like the ribs of an umbrella from a central pole and the bottom portion of each bamboo will be staked at a standing position 1.5 to 2 metres away from the central pole. These methods are known to give good production of mussels in philippines.

In India, stake method is to be developed in shallow suitable areas. Experimental trials conducted at Vizhinjam bay using transplanted bamboo poles has been found successful and the production potential is given in table I and II. At Madras also this experiment is conducted at Kovalam in the open sea.

BOTTOM CULTIVATION OR RELAYING IN FAVOURABLE AREAS

This method, being the simplest, has been practiced in Great Britain, Ireland and many of the European countries including Denmark and West Germany (Korringa, 1970) and has become the chief method in Holland (Lambert, 1951) and Dutch mussel production has reached 1,00,000 tonnes per year (FAO, 1970). Areas of 5 to 10 hectares are alloted to farmers as mussel parks on a rental basis by the Government. Seeds are first transplanted to shallow grounds and subsequently to deeper areas (Havinga, 1956) and thinning is done to avoid overcrowding and for faster growth (Iverson, 1968; Havinga, 1964). As a very thriving industry, bottom cultivation is a mechanised activity in Halland using dredges of capacity 40 tonnes per hour (Walne, 1963). In Norfolk, England the annual output per man reaches 50-60 tonnes using hand net, rake, fork and small boat (Davies, 1968).

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However, in India this method is yet to be developed and suitable areas are to be identified for introducing the bottom culture of mussels.

SYSTEM DESIGN FOR MUSSEL CULTURE IN INDIA

The foregoing account gives a general picture of the various types of culture practiced in many of the developed countries and in India. Small, medium and large-scale culture of mussels is to be taken up by identifying suitable areas in the different maritime states. Based on the experimental results obtained by stake and the rope culture method at Vizhinjam it has been possible to trace the production pattern of the brown mussels (Achary and Thangavelu, 1980) and the investment required for taking up the work by single fisherman, a group of fishermen working under a village society or an entrepreneur may work as follows:

SINGLE RAFT SYSTEM (5 m x 5 m)

I Investment	Rs
1. Bamboo @ Rs. 15 x 36	540
2. Nylon rope @ Rs. 30 x 6kg	180
3. " x 8kg	240
4. " x 50 kg	1500
5. Granite block and Iron clamp @ Rs. 40 x 4	160
6. Diesel barrel (200 litre) @ Rs. 60 x 6	360
7. Fabrication and Launching	120
8. Unforeseen expenditure and working capital	400
Total	3500

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II Operational cost

		Rs.
1.	collection of seed, seeding etc.	300
2.	Cotton netting	190
3.	Maintenance of Raft and cost of 6 drums (150 + 360)	510
4.	Unforeseen expenses	100
	Total operational cost	1100

III	Sale value of Mussel 3000 kg @ Rs. 1.6 (6 m rope @10 Kg/m x 50 ropes) per Kg.		4800
IV	Gross surplus (III-II)		3700
V	Interest on capital @ 9 %	315	
VI	Depreciation @ 20 %	700	
VII	Net surplus		2685
VIII	Income of Fisherman		2685
IX	Percentage return on Capital	76.71	
X	Income for fisherman if two rafts are maintained		5370

If two rafts are managed by a single fisherman family the returns may come to Rs. 5370/- per season provided the quality of seed and transplantation season are properly maintained and periodic husbandry work is done upto the harvest stage properly. This system can work as a small scale programme whereever seed mussels are available in the nearby area and suitable farming area is also available near the farmer's village.

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50 RAFT SYSTEM FOR MEDIUM SCALE OPERATION

		Rs.	
I	Investment for 50 rafts (Rs. 3500 x 50)	1,75,000	
	Management and other expenses @ 30 %	52,500	
	Total	2,27,500	
II	Operational cost (Rs. 1100 x 50)	55,000	
III	Sale value of mussel (3 tonnes x 50 x Rs 1600/ tonne)		2,40,000
IV	Gross surplus (III-II)		1,85,000
V	Interest on capital @ 9 %	20,475	
VI	Depreciation @ 20 %	45,500	
VII	Net surplus		1,19,025
VIII	Net profit	1,19,025	
IX	Percentage return on capital	52.31	
X	Man power requirement	4250 man days for farming work.	

This could be taken up by a group of fishermen or by cooperative activity. The suitability of the area is to be considered with priority and technical as well as management support is also to be given before committing with heavy investment.

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STAKE METHOD FOR MEDIUM LEVEL OPERATION

(System of 10,000 stakes of $2\frac{1}{2}$ m length and 1.5 m settlement area/stake per hectare)

I Investment

		Rs.
1.	Bamboo 5 m. 25000 @ Rs. 15 (split and cut into 4 pieces)	37,500
2.	Netting 2500 m.	15,000
3.	Seed (2 kg/m. and 1.5 m. each for 10,000 poles)	30,000
4.	Seeding charges Re. 1/Pole for 10,000 stakes	10,000
5.	Unforeseen expenditure	7,500
	Total	1,00,000

II	Sale value of mussels 150 tonnes @ Rs. 1600/tonne (@ 10Kg/m production for 1.5 m)		2,40,000
III	Gross surplus (II-I)		1,40,000
	Interest @ 9 %	9,000	
IV	Net profit		1,31,000
V	Percentage return on capital	131 %	
VI	Man power requirement	4000 man days for farming work.	

Even though this system is to work as a medium level operation this method also has an advantage that those fishermen who can operate with even 100 or 200 stakes adjacent to their residence, where shallow areas and seeds are available, it can be a subsidiary income for the family and such small unit system also can be introduced in suitable areas.

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TABLE I

Average production per metre by culture at Vizhinjam (Weight in Kg. including shell)

Month	Average production per metre (in Kg.)			
	By rope culture	By bamboo culture	Average for Rope & Bamboo	Retarded seed mussel
March	-	-	-	1.848
April	10.166	8.621	9.640	3.045
May	12.942	10.505	12.115	2.467
June	15.816	12.835	14.831	2.292
July	17.360	16.065	16.947	-
August	18.512	14.352	18.613	2.222
September	22.969	19.163	21.737	-
October	16.204	15.577	15.987	-
November	13.697	14.545	13.977	-
December	13.258	11.083	12.533	-

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TABLE II

Average yield of flesh in Kg. per metre by culture at Vizhinjam

Month	Average production per metre (in Kg.)			
	By rope culture	By bamboo culture	Average for Rope & bamboo	Retarded seed mussel
March	-	-	-	0.631
April	3.773	3.123	3.551	1.104
May	5.895	4.369	5.377	0.914
June	6.499	5.211	6.025	0.728
July	7.362	5.500	6.764	-
August	7.083	4.918	6.383	0.819
September	9.735	7.222	8.942	-
October	6.262	6.039	6.185	-
November	5.120	5.786	5.340	-
December	5.283	4.389	4.981	-

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FARAM TECHNOLOGY

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INTRODUCTION

Mussels are sedentary animals growing attached to hard substrates along the coastal region by means of self secreted threads called byssus. They can be transplanted from their natural habitats to any artificial hard objects in the sea where they will re-attach secreting fresh byssus threads. This unique character of mussels is taken advantage of culturing these animals. Mussel culture is being practiced in France since the beginning of thirteenth centuary. From there it spread to countries such as Spain, Holland, Belgium, Italy, Philippines, U.S.A, Australia and New Zealand, where different techniques are adopted depending on the hydrographic, social and economic conditions. In India mussel culture has been introduced only very recently. In 1971 the Central Marine Fisheries Research Institute, initiated culturing of brown mussels at Vizhinjam Bay and later successful experiments were conducted at Calicut and Madras in 1975, to study the possibilities of culturing mussels in the open sea.

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TECHNIQUES OF MUSSEL FARMING

Different methods are adopted for the culture of mussels such as the sea bottom culture, pole culture, long line culture and raft culture.

SEA BOTTOM CULTURE

This technique is widely practised in Netherlands and in a number of other European countries including Denmark and West Germany. The principle of bottom culture is the transfer of seed or juvenile mussels from areas of great abundance where growth is very poor due to over-crowding to areas of fast growth and fattening potential. Seed mussels dredged from the natural beds are spread in a thick layer in the shallow grounds. When they have reached a length of about 25-30 mm they are thinned out and transferring the excess portion to deeper areas for fast growth and fattening. When ready for marketing the mussels are dredged and dumped in a thick layer in an area of little tidal movement free from drifting sand, where they are left for 48 hours to rid themselves off silt. When mussels are 2 to 2½ years old they attain a size of about 60 to 70 mm and are ready for harvest. The chief advantage of bottom cultivation is that the mussels are for most part of the time in water and therefore feed longer. The main drawbacks are expossure to bottom predators like star fishes and crabs. and need to clean the mussels of silt.

POLE CULTURE

Pole culture is the oldest and principal method of mussel farming in France. In this method mussels are grown on rows of poles errected in the intertidal area. Mussel seed or spat is collected on spat collector poles

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errected near the natural bed. When the seed mussels reach a length of about 20 mm they are taken out at intervals and transferred to rearing poles closer to the land. The poles are 75 cm apart and are set in rows at right angle to the shore. The seeds are attached to the rearing poles in bags of fine netting which rot and fall apart after the mussels attach themselves to the poles, by byssus threads. As the mussels grow they are thinned out in order to reduce competition for food and the thinnings are transferred to another rearing posts. Another seed collection technique recently practiced in France involves suspending loosely woven ropes 13 mm in diameter and 3 meter long in the intertidal region near natural beds. Within 3 weeks seed mussels of about 5 to 10 mm size will be concentrated in the crevices between the strands of the ropes. The ropes are then wrapped around poles driven in the intertidal flats. The mussels quickly become established on the poles. The procedure is similar to the traditional method. The mussels are thinned out periodically as they grow and wrapped round other poles. By the end of second year the mussels are harvested, and marketed having reached a size of about 50 mm.

The main advantage of pole culture is that the mussels are less exposed to the bottom living predatory crabs and star fishes. Predation is further reduced by the adoption of plastic sheaths around the base of the pole. The main drawback however is that, the mussels are exposed at low tide especially on spring tide and so less time is available for feeding, growth and fattening. Also the poles are vulnerable to storms.

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LONG LINE CULTURE

The long line method of mussel farming was introduced very recently in Europe. This method is very successful in open sea mussel farming. Long lines are 50 to 75 metre long and consists of a pair of ropes strung between two parallel pair of metal, wooden or stylofoam floats. Each end of the line and sometimes the middle is anchored. Floats are spaced 3 to 7 metres apart. Mussel seeds are collected from natural beds and transplanted over the ropes and suspended from the long lines about 0.5 metre apart. The mussel growing ropes should not be allowed to touch the bottom at any time. The growth in this system is very rapid.

RAFT CULTURE OR SUSPENDED CULTURE

The raft culture technique has undergone the greatest development in recent years offering the best prospects for farming of mussels in the sheltered and open coastal waters. This method is generally used in waters more than three metres depth. The nature of the sea bottom is not important because the suspended ropes are not touching the bottom. The raft is rather a simple device. In the beginning the rafts were made from the hulls of old fishing vessels to provide floatation and the top is equiped with a wooden frame work from which the ropes are suspended. Very recently specialised rafts have been developed and the modern rafts commonly have four or more large wooden floats covered with cement or fiberglass to protect the wood from marine boring organisms. On the top of the floats frame work of wooden beams are provided, about 50 to 60 cm apart, from which the ropes are hung. The size of the raft vary but an average raft is 20 x 20 metre size

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and will accommodate 500 ropes. Recently large operators have constructed stronger rafts of about 700 square metre size for use in more deeper waters. Such rafts can hold 1000 ropes.

In India the suspended culture or raft culture method was found to be more suitable and a series of experiments are being conducted on this method in bay and open sea since 1971. Square rafts of 6 x 6 metres are found more suitable in the bay whereas rafts of the size 8 x 8 metres are found to be ideal for the open sea conditions. The main frame work of the raft is made of teak wood poles having 6 to 8 metres length and 20 to 35 cm girth. In the open sea rafts are made of 10 numbers of teak poles whereas the rafts in the bay are made of only 8 numbers of teak poles. The poles are tied together using coir and nylon ropes of 5-7 mm thickness in the shape of a square raft. The raft is provided with a trellis work of 12 numbers of solid (Kallan) bamboo poles of 12 cm diameter, which were tied to the main frame work of teak wood poles. Nylon ropes are found more durable and strong when compared to the coir ropes. Five to six empty sealed metallic drums of 200 litres capacity are used as floats. These drums are tied to the main frame work of teak wood poles, at four corners and at the centre. The number of floats have to be increased as the weight of the raft increases due to the growth of mussels, so as to keep the raft floated well above the water level inorder to avoid the damage caused by marine borers and foulers. A few wooden planks are fixed over the raft to provide working space.

The rafts are towed to the farm site with the help of a mechanised boat. Two to three grapnel type or danfarth

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types anchors each weighing 100 to 125 kg are used for anchoring the raft in position. Tested iron chains of 11 to 13 mm line diameter size having a length of about 3 to 4 times the depth of the farm site are used as anchor chains. Proper anchoring is of great importance especially in the open sea. After anchoring it has to be checked if possible with the help of divers. Flags and warning wink lights are to be provided to keep the fishing or sailing vessels away from the farm area. In the bays iron anchors and anchor chains are not necessary because of the calm nature of the water. Granite blocks of 100 kg weight are used as anchors. These granite blocks are drilled at the centre and anchor clamps are provided to tie the 16 mm nylon ropes to use as anchor ropes. Four such anchors are used one at each corner of the raft. When a series of rafts are used in the bay the number of anchors can be reduced. but in the open sea each raft has to be anchored separately.

CULTURE TECHNIQUE

Mussel seeds are to be collected from the natural mussel beds. Seed mussels of length varying from 20 to 35 mm are found to be ideal for seeding. Seeds collected from the submerged rocks are far better than those from the intertidal exposed rocks, as the small mussels available over the intertidal rocks may be of stunted growth. Before transplantation seeds are to be cleaned properly in sea water to remove the adhering mud particles and epifauna. Mussel seeds can live out of water for about 24 hours provided they are not exposed to sun. Transportation of seeds from the collection centres to the farm area and the whole seeding process has to be completed within this period. The seed is generally transported in gunny bags in moist condition. Seeds can be stored in large cement tanks

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provided with sea water circulating system. In such tanks the seeds can be kept for 2 to 3 days.

Nylon ropes of 14 mm diametre or coir ropes ranging from 20 to 25 mm diametre are used for seeding. The coir ropes are more ideal for the initial attachment of the seed mussels due to its rough fibrous nature, but they are not durable. They can be used only for one season. Nylon ropes can be used for a minimum of 4 seasons. The length of the rope used for seeding is decided according to the depth at which the rafts are anchored. Experiments have shown that 6 to 10 metre length of the rope is ideal for seeding. Increasing the length of the rope is not advisable since there is every chance of the rope getting entangled or twisted each other due to water currents. About 750 to 1500 gm of juvenile mussels can be seeded to one metre length of the rope. The seeds are kept around the rope and securely attached by enclosing and stitching in knitted cotton or bandage cloth of 25 cm width. The knitted banian cloth having 5 mm mesh size are more suitable because they disintegrate quickly and have more elasticity. Before seeding small wooden pegs or spacers are inserted to the ropes at intervals of 40 to 50 cm to avoid slipage of mussel seeds from the rope after seeding. In the upper portion of the rope about one metre is left free for tying the rope to the raft. The seeded ropes are to be suspended from the trellis work of bamboo poles of the raft at about 0.5 to 1 metre apart with the lower free end about 2 metre above the bottom, for eleminating the bottom predators. The seed mussels get attached over the ropes within 2 to 3 days and the cloth cover disintegrates in sea water within 10 days.

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MAINTENANCE OF RAFTS

Periodic visit to the farm is essential for the inspection of the rafts and suspended ropes. Oil barrels used as floats may develop holes, they have to be replaced immediately. The damages caused to the frame work of the raft should be attended to immediately. Due to the increase in weight of mussels raft show a tendency to sink, more floats have to be provided. Occassional thinning of the over-crowded mussels from the ropes may be necessary and these thinnings can be transplanted on to other ropes. If the water in the farm area gets polluted due to red-tide or blooms of other toxic marine organisms etc, the rafts have to be towed to safer areas. Measures against unusual predation as noted at Vizhinjam bay in 1979 (Appukuttan,MS) are also to be taken.

Spawning of mussels will take place in the farm much earlier than in the natural beds. In the Calicut area green mussels in the farm will spawn throughout the season. Artificial spat collectors like roof tiles, cement blocks asbestose sheets, strings of coconut shells, split bamboo poles, coir ropes, frilled nylon ropes and iron happas covered with nylon netting can be used for the collection of spat from farm in the bay as well as in the open sea. Roof tiles, iron happas and frilled nylon and coir ropes are ideal material for spat collection.

The harvesting of the mussels has to be done when they are in the prime condition. The brown mussels reach this condition 5 to 6 months after seeding, when they reach a size of 50 to 60 mm. The green mussels will attain this condition 5 to 6 months after seeding when they reach a size of about 70 to 90 mm. But in the open sea mussel culture, very often, the onset of monsoon forces a premature harvest, whereas in the case of bays harvesting can be made as and when the mussels grow to marketable size.

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TECHNICAL SESSION IV PRODUCTION AND ECONOMICS	CMFRI-CAS/MF/80/ BP - 12

GREEN MUSSEL PRODUCTION AND ECONOMICS AT CALICUT

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In India a sizable commercial fishery for green mussels exists along the Malabar coast only. The green mussel beds extending from Calicut to Kasargode is roughly estimated to spread to an area of 2500 hectares. The beds are scattered from the intertidal region to an area of about 10 metres depth. In this area annual potential stock of about 8000 metric tonnes of mussels are available. From the important mussel landing centres in the Malabar region an annual average of about 2500 tonnes of mussels are collected.

The mussel fishery extend only for a period of 8 to 9 months from September to May. During June, July and August mussel picking is not possible due to the monsoon. The important fishing method is collection of mussel by diving. The divers go in a canoe or floating logs locally known as "mutti" to the submerged rocks away from the shorp. They dive and collect mussels by hand using share iron chisel for scraping the mussels from the rocks. About 800 people

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are engaged in mussel fishery from Kasargode to Challium near Calicut. Out of this about 400 are actual divers who collect mussels from the submerged rocks and the rest are engaged in marketting. The fishing is carried out in low tide, calm water and sunny days. The fishing duration varies depending upon the availability and market demand. Generally the fishing time is from 07.00 hours to 14.00 hours. Fisherman can collect on an average about 45 kg of mussels per day. He sells this to the merchants at the landing centre at a fixed rate of Rs. 0.50 per kg. The mussel fishing fisherman thus earns about Rs 22.50 per day. One kg of mussel in the market fetches a price of about Rs. 1.25.

MUSSEL PRODUCTION IN CULTURE SYSTEM

In the culture system a standard raft of the size 8 x 8 m can hold 100 mussel ropes each of an average length of about 6 metres. One metre length of this rope is seeded with about 750 gm of mussel seed. At this rate for seeding all the ropes in a raft about 450 kg of seed will be necessary. After five months one metre length of the seeded rope can produce about 12 kg of mussels and the production from one rope will be 72 kg of mussels. The whole raft can thus produce 7200 kg of mussels.

ECONOMICS OF MUSSEL CULTURE

The economics of mussel culture mainly depends on the market price of mussels. At present one kg of cultured mussel fetches price of about Rs. 1.25. On the basis of this the expenditure and income from a single mussel culture raft are given below:

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CAPITAL COST OF ONE RAFT FOR 3 YEARS

1.	Teak poles 10 Nos (Rs. 25/- per pole)	250.00
2.	Bamboo poles 12 Nos (Rs.15/- "	180.00
3.	Anchors 100 kgs 2 nos	1000.00
4.	Anchor chain 100 kgs	1400.00
5.	Nylon ropes 6 kgs	170.00
6.	Shackles etc.	250.00
	Total	3250.00

RECURRING EXPENDITURE

1.	Oil drums 5 Nos Rs. 100/-	500.00
2.	Coir ropes 300 kgs	1500.00
3.	Knitted cotton cloth	400.00
4.	Seeding expenditure	200.00
5.	Expenditure for farm management	400.00
	Total	3000.00

ie., The total expenditure for 3 years
3250 + (3000 x 3) Rs. 12250.00

Salvage value of the raft after 3 years Rs 500.00

Depreciation of the raft after 3 years Rs 2250.00

One mussel culture raft can hold 100 mussel culture ropes and the average production per rope in one year is 50 kgs of mussels.

So the total yield from a raft per year =50x100=5000 kg of mussels

Average price for 1 kg mussels Rs. 1.25

The total return for 1 year = 5000 x 1.25= Rs. 6250.00

ie., the average return for 3 years =6250 x 3=Rs 18750.00

Total profit at the end of 3 years = Total revenue - (Total cost including depreciation - salvage value) =

18750.00 (12250 + 2250 - 500) = 18750-1400 = 4750.00

Therefore the profit for 3 years = Rs 4750.00

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Till recently mussel was considered as a poor man's food, but of late it is becoming more and more popular. With the increasing demand, margin of profit from the system would be considerably enhanced.

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TECHNICAL SESSION IV PRODUCTION AND ECONOMICS | CMFRI-CAS/MF/80/BP-13

BROWN MUSSEL PRODUCTION AND ECONOMICS AT VIZHINJAM

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INTRODUCTION

Brown mussel is distributed along the Southwest Coast of India and is much relished by the people along the coastal area. Considering the vast potentials of this resource, the Central Marine Fisheries Research Institute carried out a preliminary survey to assess the stock along the coast and also initiated experiments on culturing the mussel at Vizhinjam from 1973 onwards. The abundance of planktonic larvae, the dense settlement of spat in the intertidal rocky area around Vizhinjam and the availability of a protected bay suitable for culture work were the important factors in initiating mussel culture experiments at Vizhinjam. Initial experiments in the Bay have shown that Spanish method of raft or rope culture yielded higher than the natural production and is most ideal method of culture to this area.

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THE NATURAL MUSSEL PRODUCTION

At Vizhinjam the mussels are found attached to rocks and other hard objects along the intertidal area upto a depth of about 15 meters. Generally mussels do not move about once they settle over these substrata. So far no systematic attempts were made to estimate the potential and the exploited stocks of mussels from Indian Coast. Jones and Alagarswami (1973) made a preliminary survey of the mussel fishery resources of India and estimated the total mussel landing as roughly 1000 metric tonnes. Fo Vizhinjam area the total landing was 180 tonnes. A recent survey conducted for estimating the potential stock and exploited stock of brown mussels in the natural bed revealed that the Vizhinjam area, from Kovalam to Chowarah, 10 Km stretch of coastal line with continuous stretch of intertidal rocks with dense settlement of brown mussels is highly productive. For calculating the potential stock in the natural bed, number of randum samples were taken from unit area at different centres around Vizhinjam. Exploited stock was estimated from the average catch per person per day, average number of persons engaged in mussel picking and number of active fishing days.

The fishing starts from October and lasts till May with a peak during December to February in this area. The fishermen reach the mussel bed by swimming or by catamarans and collect mussels ranging from 45 to 60 mm size. The mussels attached to hard substrata are scraped out using sharp chissel and collected in nylon bags or 'mal' tide around their waist. From deeper waters mussels are collected by diving.

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The important mussel centres around Vizhinjam Viz. Kovalam, Avaduthura, Pulloorkonam, Vizhinjam, Kottappuram, Karimpally, Mulloor-Pulinkudy and Pulinkudy-Chowarah were selected for estimating the potential stock and exploited stock. The total estimated mussel bed for the whole area is 17.44 ha. The random sampling revealed that 5kg of mussels are found in a square metre area and thus the potential stock could be estimated as 872 tonnes. Regarding the exploited stock the average catch per person per day during an active fishing season is 14 kg. and the total fishermen engaged in mussel picking are roughly 325 per day. Average fishing days for a season is 50. Based on these details the total exploited stock could be computed as 227.5 tonnes of mussels every year. This shows that out of the potential stock estimated, only 26 per cent is being exploited every year. A precise estimate for Vizhinjam centre alone by regular sampling from 1976-79 has revealed that the yearly exploited stock varied from 4 to 15 tonnes per hectare depending on the variation in the settlement rate in the natural bed. From enquiry and information gathered from fishermen, it was understood that the trend was the same at other centres also. Mostly Harijan and Muslim fishermen go for mussel picking in this area. Method of disposal of exploited stock from all these centres are identical. The mussels brought by fishermen are cleaned, graded and sold in numbers to the merchants. The mussel is taken to interior markets by local merchants as head load or cycle load packed in gunny bags or baskets. The average size of shell varies from 45-60 mm. and the large sized mussels locally called 'muthuva' varies from

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65-80 mm. The main market centres for brown mussel are located around 20 kilometers radius of Vizhinjam and nearby places.

100 numbers of mussels cost Rs. 3 to 7 and the average price calculated from the disposal rate for the last four years is Rs. 4. Large mussels ('muthuva chippi') are sold usually for Rs. 6 to 10. From observation it is noted that 100 numbers of marketable sized mussels weigh 3 kg. Keeping the total exploited stock as 227.5 tonnes the estimated cost of mussels exploited from Vizhinjam area is roughly Rs. 3,00,000 and the income of an active fisherman per day during fishing season is about Rs.18.50.

MUSSEL PRODUCTION IN CULTURE SYSTEM

Among the five different types of mussel culture methods viz. sea bottom culture, pole culture, rack culture, long line culture and raft culture practiced in different countries, raft culture was tried at Vizhinjam bay on experimental basis right from 1973. It was found that raft or rope culture is suitable for large scale production of brown mussel at Vizhinjam. Similar experiments conducted in the coastal waters of Calicut, Madras and Goa on green mussels also proved successful (Kuriakose (MS) Rangarajan (MS) and Quasim et al (1977).

Experiments conducted at Vizhinjam Bay has shown that Spanish type of raft ranging from 6 x 6 meters to 10 x 10 meters, fabricated with teakwood poles and bamboos lashed by coir or nylon ropes with metal drums of 200 litre capacity as floats, can be used for raft culture

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with minimum capital investment and substantial yield. For mooring the rafts, iron anchors or granite blocks with anchor chain are used inside the bay and open sea. At Vizhinjam bay the culture could be conducted throughout the year whereas in the open sea it was restricted for five month period as the monsoon was severe in this area affecting the position of rafts. Experiments conducted so far in the bay and open sea has shown that the ideal length of the seeded rope which can be suspended in the rafts is in between 5-6 meters and the growth rate of mussels in the upper 2 meters of the rope was found to be fast. While comparing the growth rate in the open sea and bay it was found that brown mussel grow faster in the open sea condition. Seeding of mussel done during November-December period could be harvested from May onwards adjusting the local demand. The average weight of mussel seed used for seeding one meter rope varies from 1.4 to 2 kg. and the average production is 10-12 kg. per meter inside the bay within 8 months. In the Vizhinjam bay by raft culture method the mussels attain the model size of 55-60 mm. within 8 months resulting an average growth rate of 2.94 mm. per month. This size is ideal for harvest as the ratio of meat weight to total weight was observed as 41.31% (May-June period). In a single raft of 6 x 6 meter size 50 numbers of 6 meter long seeded ropes could be accommodated. Based on this it is estimated that from a single raft 3 tonnes of mussels could be harvested in a season. It is quite possible to accomodate a minimum of 50 such rafts in a hectare area and thus the production computed per hectare area is 150 tonnes. Open sea mussel culture experiments

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conducted during 1978 and 1979 in the coastal waters off Vizhinjam showed that the production rate is comparitively higher than that observed in the bay. The seeded ropes of 5 meter length reach harvestable size within 5 months in the open sea and per meter production is estimated as 15 kg. Thus the production per hectare area is calculated roughly as 180 tonnes.

To understand the economics of experimental brown mussel culture, the details of expenditure and anticipated income from the yield for an year are given below.

Capital investment for 6 x 6 metre raft inside the bay with 50 seeded ropes.

1. Teakwood poles	8 nos.	@ Rs. 20.00	Rs. 160.00
2. Bamboo poles	12 nos	@ Rs. 15.00	Rs. 180.00
3. Nylon rope (5 mm.)	7 kg.	@ Rs. 30.00	Rs. 210.00
4. Nylon rope(12 mm.)	60 kg.	@ Rs. 30.00	Rs.1800.00
5. Anchor (granite blocks with anchor clamp and anchor rope)	4 nos.	@ Rs. 40.00	Rs. 160.00
6. Fabrication and launching charge			Rs. 150.00
7. Oil drums of 200 litre capacity.	6 nos.	@ Rs. 60.00	Rs. 360.00
8. Wages for seeding and other expenditure			Rs. 120.00
9. Mosquito netting			Rs. 180.00
		Total	Rs.3320.00

Out of these items mentioned above, materials used for raft construction and the nylon rope used for

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seeding can be used subsequently for 4-5 seasons, without incurring additional capital investment. It could be observed that recurring expenditure will be incurred from the second season onwards for replacing oil drums, mending and repair charges of raft, wages for seeding and cost of mosquito netting. Thus recurring expenditure is much low and the profit rate may increase after the first harvest. In the open sea mussel culture the initial investment will be higher than that of Bay rafts since, iron anchors and tested iron chains are to be used for positioning the rafts. Recurring expenditure for launching and positioning the raft and beaching the raft after harvest are the additional expenditure to be met with every year for open sea mussel culture.

Details of rope culture of brown mussel at Vizhinjam

Particulars	Bay	Open sea
1. Time taken for harvest	8 months	5 months
2. Average marketable size range	55-60 mm.	55-60 mm.
3. Length of seeded ropes used	6 meter	5 meter
4. No. of rope per raft (6 x 6 meter)	50 nos.	50 nos.
5. Production per metre of rope in a season.	10-12 kg.	15 kg.
6. Production per raft	3 tonnes	3.75 tonnes
7, Production per hectare	150 tonnes	187.5 tonnes
8. Return from a single raft	Rs.4800.00-6000.00	Rs. 6000.00-7500.00
9. Value of marketable size mussel per kg.	Rs.1.60 - 2.00	Rs. 1.60 - 2.00
10. Net profit for a season from a single raft.	Rs.1480.00-2680.00	....

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REMARKS

In recent years mussels around Vizhinjam are being exploited indiscriminately due to greater demand in the market. It is also observed that compared with previous years mussel settlement is also poor in this area, but the number of fishermen engaged in mussel picking has considerably increased. Mussel culture experiments at Vizhinjam has revealed that production from raft culture is much higher than that of the natural bed and further if farming is taken up in the open sea the yield can be increased. Keeping the rafts in the open sea condition during monsoon period is felt much difficult and attempts are yet to be made to find out suitable teahnique to do mussel culture throughout the year in the open sea condition. Though attempts to raise good quantity of mussel seed by releasing artificial spat settlers in the farm area have proved successful, earnest effort to produce large quantities of mussel seeds by hatchery system is to be made for large scale mussel culture.

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TECHNICAL SESSION IV PRODUCTION AND ECONOMICS	CMFRI-CAS/MF/ 80/BP -14

MUSSEL PRODUCTION AND ECONOMICS AT KOVALAM (TAMILNADU)

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Kovalam, a fishing village 35 km south of Madras was selected for open-sea mussel farming experiments in 1976. Based on the early results and noting its potentialities an Operational Research Project involving the local fishermen was started in this village in 1978.

The green mussel, Perna viridis, is sparsely distributed in the Coromandal Coast. There is a well established mussel resource at Ennore, 20 km north of Madras. The mussels are found attached to the concrete pillars of the dredging pier constructed into the sea near the mouth of the Ennore river. There is also a mussel bed in the river about one kilometre from the mouth near the Railway bridge. Here the mussels are found attached to dead oyster shells imbedded in the mud. In Madras city itself there is a small settlement of mussels in the rocks dumped in the sea off the outer

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harbour wall. Farther south in Pondicherry and Cuddalore there are small settlements on the pier structures. At Cuddalore the harbour wall at the mouth of the river has a mussel settlement.

At Kovalam, there were no mussels till 1976. Spat and parent stock was first introduced here by the Central Marine Fisheries Research Institute, when the open-sea mussel culture programme was started. They got quickly acclimatised to the new environment and spat fall was noticed the same year. Spat settled in both the submerged rocks and the patches of partially exposed rocks in the intertidal region of Kovalam bay. But still the natural beds have not developed to any sizeable proportion to support a fishery.

At present there is a small retail outlet for mussels in Madras city and in Pondicherry. Mussels of 75 to 80 mm size are collected by a few fishermen and sold in these markets for a period of about three months from July till the onset of the North east monsoon in October.

A market survey conducted recently in Madras has shown that mussels are sold in six markets all over Madras by 8 people. Each person brings to the market 1 bag weighing about 45 kgs (1500 nos) at a time. Except in Purasawalkam market where it is sold every day during these three months, in the other markets it is sold only on sundays. In Purasawalkam and Jambazar market the intake on sundays is 2 bags. Thus on Sundays about 300 kgs of mussels are consumed in the city and on other days of the week at Purasawalkam a total of 270 kgs is consumed,

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totalling 630 kgs per week or about 2½ tons in a month. An estimated 5 to 7 tonnes of mussels are consumed in Madras and the entire stock is brought from Ennore.

This is purely a family avocation and one member of the family collects the mussels at Ennore in the early hours of the morning and it is brought to the Madras market by the womenfolk, along with crabs in the fish van which plies regularly between Ennore and Madras. They reach the markets by about 9 AM and by 11 AM the commodity is sold and they return back to the village in the same van. In most of the markets it is sold at Rs 5/- per hundred (3 kilos). Only in Thousand lights and Jambazar markets the rate varies from Rs. 5/- to Rs. 8/-. On an average a woman earns Rs 45/- per day by selling mussels. Deducting collection, transport and handling charges, it could be safely assumed that a ton of mussels costs Rs. 1,500/-. Therefore the total value of mussels sold at Madras will be in the order of Rs. 7,500 to 10,000/- per season. Mussels are sold in the fresh condition with shells. No cleaning is done. The buyers are mostly people from Kerala and in Thousand lights area it includes some Chinese.

As already mentioned the natural resource at Ennore is small and it cannot possibly supply more than 7 tons in a year. Experiments were therefore started at Kovalam to culture mussels and to demonstrate its economic viability. Culture experiments on mussels were tried by the following system:

1. The floating raft system for rope culture.
2. Pole culture
3. Submerged raft with rope culture.

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In all these systems, mussels grew well and attained marketable size in about five months time. The rafts were anchored in the open sea in the 8 metre depth area while pole culture was tried in 4 metres depth area. The rough sea conditions of the east coast, however, did not permit the floating raft and the poles to be kept at sea continuously. This necessiated an innovation of a submerged raft and this has withstood the rough sea conditions. It is seen from our experiments that any one of these methods could be selected to suit local conditions along the Indian coast.

The comparative cost and economics of the three systems are given in Table 1.

At present only 5 to 7 tons of mussels from the natural bed at Ennore is being marketed in Madras city for 3 months in a year. This could be increased by adopting any one of the culture methods described above. It would be seen from the tables that the non-recurring expense on anchor and anchor chains in the raft culture method accounts for nearly 50% of the total cost and in the pole culture the poles have to be replaced once in 5 years time. The yields from these systems are very encouraging and by judicious use of space and material a good profit margin can be obtained. It will not be out of place to mention here that these figures are arrived at from the data collected during preliminary experimental ventures. The expenses could be reduced and profit margin could be increased by adopting suitable managerial principles when large scale production is planned.

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TABLE 1. Comparative Economics of Mussel culture

Expenditure heads	Floating raft	Submerged raft	Pole culture
Area (m^2)	25	81	100
Capacity(rope/pole/unit)	50	100	100
1. Non-recurring expenditure (Rs)			
a. Anchor (2 Nos)	880.00	880.00	-
b. Anchor/chain(2Nos)	1500.00	1500.00	-
c. Chain for float	-	720.00	-
d. Pile driving	-	-	3000.00
2. Recurring expenditure(Rs) (Once in 2 or 5 years)			
a. Casuarinapoles	350.00	-	-
b. Bamboo poles (2 yrs)			
c. Teak poles (5 yrs)	-	300.00	6000.00
3. Recurring expenditure(Rs) (every year)			
a. Floats	750.00	1620.00	-
b. Shackle	48.00	48.00	-
c. Swivel	-	92.00	-
d. Nylon ropes	250.00	250.00	-
e. Coir ropes	250.00	500.00	500.00
f. Cost of mussel bags & stitching	200.00	400.00	400.00
g. Cost of paint	100.00	100.00	100.00
Total (Rs)	4328.00	6560.00	10000.00
4. Estimated production in one harvest (kgs)	3000	6000	12000
5. Estimated value(Rs)	4500.00	9000.00	18000.00

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TECHNICAL SESSION IV	PRODUCTION AND ECONOMICS	CMFRI-CAS/MF/80/BP - 15

MUSSEL PRODUCTION AND ECONOMICS AT RATNAGIRI

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INTRODUCTION

Mussels as a world food resource have been indicated by Davies (1970), because of their great potential for culture and world wide distribution. In countries like India with high population and protein malnutrition anything that could be produced in large quantities at a cheaper cost giving animal protein is welcomed. In this respect mussels could be an answer meeting all the requirements. The culture potential for mussels yielding about one million tons at a rate of one ton per acre have been shown possible for India (Davies 1970). Experiments carried out in 1971-72 at Vizhinjam by Central Marine Fisheries Research Institute have shown that production of 60-70 m. tons per hectare (Qasim and Achari 1972). Recently it has been stated that open sea farming of mussels yield a production rate of

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150 tons for brown mussel and 235 tons for green mussel per hectare (C.M.F.R.I. 1978) but highest production with an annual production of 480 tons of mussels per hectare has been computed by Qasim et al (1977). The results of these experiments given above clearly indicate that the forecast of Davies (1970) of potential production of one million tons at the rate of 2.5 tons per hectare per year is far too low when compared to 480 tons per hectare per year. However, they certainly indicate the tremendous potential mussels have and mariculture of mussels will go a long way in future in substantially increasing the marine food production.

The family Mytilidae is represented in Indianwaters by two species viz. Perna viridis the green mussel and Perna indica the brown mussel. The detailed distribution of these two species in India is given by Jones and Alagarswami (1973). The green mussel has a wider distribution whereas the brown mussel is restricted to the southern most part of the Indian peninsula.

Occurrance of the green mussel Perna viridis in Ratnagiri which envinced interest in the animal led to study their growth in nature and a feelar trial in culture. The growth in culture was found to be faster (Ranade et al; 1973). A project entitled, "Raft culture of the green mussel Perna (Mytilus) viridis" was therefore, formulated and submitted to I.C.A.R. for financial assistance. The project was cleared by I.C.A.R. in June 1977 and funds amounting to Rs.44,300 were made available for a period of three years. The work was started in October 1977 and the results obtained so far have been reported in this paper. The authors wish

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to express their sincere thanks to I.C.A.R. for financial assistance and for the permission to publish the results of the investigations.

MATERIAL, METHODS AND DISCUSSION

A survey of seed of the green mussel along the coast of Ratnagiri did not reveal any dense spat fall useful for culture operation. It was, therefore, decided to collect seed mussels from Velsao, Goa where density of spat of 11000/m^2 has been reported (Qasim et al; 1977). The seed collected from this place was transported in plastic pools on board the Research Vessel "Varsha". The deck washing pump of R.V. "Varsha" was used to keep the sea water in continuous circulation in the plastic pools enroute to Ratnagiri. This method was found to be quite satisfactory for transportation of seed from Goa to Ratnagiri. The mortality during transport was hardly 2-3%, possibly because of injury to mussel seed during collection.

A square wooden raft fabricated at the research station was taken to the shore and toed to the mooring site in Bhagawati Bay by R.V. Varsha. The details of the raft are given below:

1) Shape : Square
2) Overall dimensions: 5 x 5 m.
3) Space available for culture : 4 x 4 m.
4) Length of wooden poles : 5.0 m.
5) Length of bamboos : 5.0 m.
6) Height of drums : 1.25 m.
7) Girth of drums : 0.7 m.
8) Weight of anchors : 45 kgs each

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9) Length of nylon rope used for anchorage: 20 m.
10) Number of wooden poles required : 9
11) Number of bamboos required : 11
12) Number of drums required : 4
13) Number of anchors required : 2
14) Quantity of coir rope required : 20 kgs.
15) Quantity of nylon rope required : 36 kgs.
16) Quantity of anti-corrosive paint required: 20 kgs.
17) Number of man hours required for fabrication : 15 hrs.

The method of attachment of mussel seed to the hanging ropes was similar to that described by Qasim et al; (1977). From the raft of specifications given above 75 ropes could be suspended.

The details of rope cultivation of mussels are given below:

1)	Time taken for commercial production	.. 6 months
2)	Average marketable size	.. 60-62 mm
3)	Average weight of the marketable size	.. 20 gms.
4)	Cultivable area of the raft	.. 16 m^2
5)	Number of 3 m. long ropes per raft	.. 75
6)	Average annual production per rope in 6 months	.. 7.0 kgs.
7)	Average annual production per rope (2 harvests)	.. 14.0 kgs.
8)	Average annual production per raft(16m^2)	1050 kgs.
9)	Annual production per m square	.. 65.62 kgs.
10)	Value of mussels per raft per year @ Rs. 4/- kg.	.. Rs. 4200

Based on the above production rates the economics of raft culture of mussels at Ratnagiri by a fisherman family is worked out and given below:

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Economics of a 25 m^2 raft :

I) Capital expenditure:

1) Cost of drums (4 Nos.)	.. Rs.	400.00
2) Cost of wooden poles (9 Nos.)	.. Rs.	99.00
3) Cost of bamboos (15 Nos.)	.. Rs.	75.00
4) Cost of anchors (2 Nos.)	.. Rs.	360.00
5) Cost of Nylon ropes (36 kgs,)	.. Rs	1080.00
6) Cost of coir ropes (20 kgs.)	.. Rs.	80.00
7) Cost of anticorrosive paint (20 kgs.)	.. Rs.	50.00
8) Cost of labour for fabrication	.. Rs.	56.00
9) Cost of transport and mooring of raft	.. Rs.	200.00
10) Cost of one tony	.. Rs.	1200.00
Total .	Rs.	3600.00

II) Recurring expenditure:

1) Servicing and upkeep of the raft	.. Rs.	200.00
2) Cost of seed 150 kg @ Rs. 2/- kg.	.. Rs.	300.00
3) Cost of transport and hanging	.. Rs.	400.00
4) Depreciation of raft @ 33%	.. Rs.	710.00
5) Depreciation of tony @ 5%	.. Rs.	60.00
6) Loan repayment in 5 years	.. Rs.	720.00
7) Interest on diminishing balance @ 11%	.. Rs.	240.00
8) Miscellaneous	.. Rs.	70.00
Total	Rs.	2700.00

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III) Profit and Loss:

1) Sale of 1050 kgs of mussels @ Rs.4/-kg.	..	Rs.4200.00
2) Interest on depreciation fund @ 10%	..	Rs. 77.00
Total	Rs.	4277.00
3) Less recurring expenditure	Rs.	2700.00
4) Net profit	Rs.	1577.00
5) Rate of return on investment		144%

Althouth the rate of return on the investment is good the net profit of Rs. 1577/- from operating one raft is not enough to maintain the family of six for a fishermen. It is, therefore, necesssary that each unit of fishermen family operates four rafts at a time. Economics of operation of four rafts by unit of fishermen family is given below:

I) Capital expenditure:

1) Cost of tony	...	Rs. 1200.00
2) Cost of fabrication of four rafts	...	Rs. 8800.00
3) Cost of transport and mooring	...	Rs. 800.00
Total		Rs.10800.00

II) Recurring expenditure:

1) Servicing and upkeep of the rafts	...	Rs. 800.00
2) Cost of seed 600 kg @ Rs. 2/kg.	...	Rs. 1200.00
3) Cost of transport and hanging	...	Rs. 1600.00
4) Depreciation of rafts @ 33%	...	Rs. 2940.00

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5) Depreciation of tony @ 5%	...	Rs. 60.00
6) Loan repayment in 5 years	...	Rs. 2200.00
7) Interest on diminishing balance @ 11%	...	Rs. 730.00
8) Miscellaneous	...	Rs. 170.00
Total		Rs. 9700.00

III) Profit and Loss:

1) Sale of 4200 kgs of mussels @ Rs. 4/kg.	...	Rs.16800.00
2) Interest on depreciation fund @ 10%	.	Rs. 300.00
Total		Rs.17100.00
3) Less recurring expenditure	...	Rs. 9700.00
4) Net profit	...	Rs. 7400.00
5) Rate of return on the investment	...	168%

The economics of operating four rafts by a unit of fisherman family given above clearly indicates that it is more profitable to operate your rafts than one and earning a decent per capita income which is much above the poverty line.

The main constraint for mussel culture in Ratnagiri district is the non-availability of seed mussels in large quantities which increases the cost of culture operation by 29.2% because the seed is to be brought from Goa. This is compensated by the high price of mussels at Ratnagiri

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(Rs. 4/- per kg.) which is considered a delicacy next to oysters and because of scarce availability. It is estimated that in the district only 1.4 m.tons of mussels are caught (Jones and Alagarswami 1973). With culture operations and large quantities available for sale the price is likely to fall down to Rs.3/- per kg. and subsequent reduction in the net profit to Rs.3200/-. To offset this reduction in earnings, the raftmen will have to increase the production per unit space and time by increasing size of the raft and by utilizing open sea for mariculture of mussels where better production is achieved.

The various production rates of mussels culture on ropes at various places on the west and east coast of India need to be compared on some common grounds. For this it is necessary to standardise a size of raft, pattern of fabrication, quantity of seed to be attached, species to be used etc. This will give a correct comparison of production rates and economics at various places which will help in the future on deciding the policy for development of culture of mussels in the country.

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TECHNICAL SESSION IV PRODUCTION AND ECONOMICS | CMFRI-CAS/MF/80/BP-16

PRODUCTION AND ECONOMICS OF MUSSELS IN GOA

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A B S T R A C T

The green mussel (Perna viridis. L) widely distributed along the Indian coastline, has great potential as a protein rich cheap food. The National Institute of Oceanography, India, has succeeded in developing a technique for the farming of green mussels on ropes suspended from floating rafts.

Raft culture of mussel gives an annual yield of 184 kg/m^2 and in terms of area, it works out to be 480 tonnes per hectare per year. The technique ensures continuous harvesting and is feasible, both technically and economically.

Cost of production is about Rs 375/m^2 and the value of mussel meat produced is about Rs. 1100/m^2, thus giving a high rate of return of 181%. The technique developed is accordingly an appropriate system of

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aquaculture involving minimum use of capital investment, low operational cost, production of low price high quality seafood having effective market demand and involvement of unskilled manpower.

The paper gives details about the criteria for site selection, fabrication of rafts, technique of transplantation on ropes, growth, food value, fouling, predators and parasites. Economics along with cost-benefit analysis has been worked out. Constraints and advantages of raft culture of mussels are discussed.

INTRODUCTION

The mussel culture in Goa was initiated by National Institute of Oceanography in early 1974. The mussels, both green and brown, occur abundantly along the shores and in estuaries of Goa and are greatly relished as food by the local population. The average market price in 1979-80 for mussels with shells was about Rs. 6 per kg and the mussel meat is sold at the rate of Rs. 10 per kg. The annual yield of mussels in Goa from natural beds is about 200 tonnes.

Our earlier studies (Qasim, Parulekar, Harkantra, Ansari and Nair 1977) on green mussels have revealed that due to excessive intertidal exposure and heavy mortality mainly due to predation, the attainment of marketable size in natural populations, takes more than a year or so. Considering the fact that the mussels are filter feeders and hence, if grown under constant submerged condition,

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wherein food will be available all the time and if the rate of predation by natural enemies is monitored then the growth progression will improve resulting in the attainment of marketable size in less time.

CRITERIA FOR SITE SELECTION

As reported earlier (Qasim, Parulekar, Harkantra, Ansari and Nair 1977; Parulekar, Ansari, Harkantra and Nair 1978) the success of mussel culture on floating rafts, depends on the interplay of a number of biotic and abiotic factors, some of which may act as limiting factors and hence the selection of site should strictly be based on the baseline information about environmental and biological characteristics. In the course of our work on raft culture of mussels, the first site in the Caranzalem Bay of Mandovi estuary, inspite of a number of plus points had to be abandoned due to severe sub-aerial erosion during southwest monsoon season, resulting in the dislodging of rafts from mooring.

Important criteria to be observed are:

1. A good knowledge of currents, tides, waves, sediment transport and winds prevailing in the locality.
2. Baseline information on the seasonal changes in temperature, salinity, dissolved oxygen, suspended load, heavy metals, polychlorinated biphenyls, organochlorines etc.
3. Thorough knowledge of primary productivity, organic matter, detrital content, bacterial flora etc.

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4. The proposed site should not be in the vicinity of industrial and sewage outfall.

FABRICATION OF RAFT

The rafts used are of wood, preferably of cheap quality like "mathi", which is very durable and readily available, locally. To start with smaller rafts of 6.25 m^2, surface area, with four heavily tarred metal barrels were used. In later stages, even bigger rafts of 15 m^2 were used but difficulties in fabrication, towing, mooring and servicing were experienced. Moreover, during inclement weather, the smaller rafts are easy to manage in cases of breakdown. The rafts are anchored with steel anchors, and steel chains (15-20 m in length) heavily tarred to reduce deterioration. The fabrication of rafts is done on the shore adjoining the site and towing and mooring is done either by a small mechanised boat or even by a country craft. The servicing of raft which includes tightening of ropes, replacement of barrels etc, is done within every 3 months. The cost, including material, labour charges for fabrication, servicing etc, of each raft of 6.25 m^2 area is Rs. 1750/- and Rs.2900/- for a bigger raft of 15 m^2.

TRANSPLANTATION OF SEEDS ON ROPE

Mussel spats suitable for transplantation are abundantly found in Goa from September to February. The size of selected seed is 5-10 mm and these are about 4-6 weeks old. The seeds before being transplanted are kept

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in well aerated sea water for 10-12 hours.

Different type of ropes, like coir, manilla, nylon etc. were tried but in the long run, the nylon ropes are found to be most suitable. The rope (12 mm diameter) of desired length (3 m) is placed over strip of cotton mosquito curtain cloth of about 35 cm width, and mussel seeds arranged on either side. Each rope was seeded with 600-700 young mussels. To prevent the clumping of mussels, small bamboo tags (about 10 cm long) are inserted through the twist of the rope at regular interval of 0.5 m. The cloth is stitched around the rope before transferring the rope to the raft. Care has to be taken so that the rope does not touch the bottom and the mussels are always, submerged. We have been using thin and short ropes as our rafts are anchored in a water column of 5-8 m depth. Moreover for handling thick and long ropes a mechanised device for hauling the ropes would become inevitable.

GROWTH

The mussels on rope grow to marketable size of 60-65 mm in less than 18 weeks. The growth of mussels is directly related to seasonal variations in environmental parameters and accordingly the growth in length is maximum (12mm/month) in premonsoon (February-May), average (10 mm/month) in postmonsoon (October-January) and minimum (8 mm/month) in premonsoon (June-September). In contrast the increase in weight is maximum in monsoon and minimum in postmonsoon. The average monthly increase in weight is 11.3 g.

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FOOD VALUE

The protein and caloric content in the rope grown mussels is higher (56.5% and 6.2 Kcal/g dry wt) than in natural population (54% and 5.6 Kcal/g dry st.). Regular monitoring of the microflora of cultured mussels also indicate that there is less intensification of pathogenic vectors than in the natural populations.

FOULERS, PREDATORS AND PARASITES

The intensity of fouling varied seasonally but at no time it assumed alarming proportions. The fouling fauna, in order of predominance are bryozoans (50%) and barnacles (35%). As the ropes do not touch the sea bottom, predations by star fishes or crabs is completely eliminated. No infection by Mytilicola sp. or trematodes has been observed. However, rarely the pea crab, Pinnotheres sp. is found in the mantle folds of the mussel.

PRODUCTION AND ECONOMICS

Prolonged breeding, intermittant spatfall and the settlement of spat on ropes, make it possible to have uninterrupted harvesting and relaying of mussels for 8-9 months in a year. As shown in Table 1, the average production per rope in 18 weeks is 18 kg of shells or 9 kg of meat, and accordingly, the annual production per raft (6.25 m^2) with 50 ropes, is 23 tonnes of mussels which works out to 184 kg meat/m^2.

The annual estimated yield (Table 1) of 480 tonnes per hectare is lower than the 600 tonnes reported (Bardach,

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Rhther and Mclarney 1972) from Spain but many times greater than that has been recorded by Qasim and Achari (1972). One of the reasons for lower yield is due to the use of smaller rafts with shorter ropes. Further refinements in the techniques to be used on commercial scale are likely to increase the yield further and reduce the cost of production. As compared to the rafts used in other countries like Spain, Netherlands, Philippine and Japan, our rafts are cheaper to fabricate and maintain but equally effective and perhaps most well suited for sea conditions along our coast.

As seen from Table 2, the value of produce per raft is Rs.6,900/- as against the cost of production which amounted to Rs. 2,450/-. This gives a gross profit of Rs. 4,450/- at a profitability rate of 181%. In fact, the rate of returns can be much more higher as the base figure of Rs. 3 per kg, used for evaluating the produce is almost 100% less than the present day market rate. Moreover, the proceeds which may accrue from the sale of empty shells (extensively used for lime making) are also not included in the return.

CONSTRAINTS AND ADVANTAGES

The major shortcomings and constraints in mussel culture, in spite of its being highly remunerative are:

i) Labour intensive operations at least in the initial phase.

ii) Losses of ropes, anchors, mussels, etc. due to tampering by inquisitive fishermen and miscreants.

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iii) Intensive care of rafts during the monsoon season due to turbulent sea conditions.

Advantages: The raft culture of green mussels has the following advantages:

a) High tolerance of mussels to wide variations in salinity, makes the species an ideal organism for cultivation in estuaries and marine environments of tropical seas.

b) Growth occurs throughout the year and culminates in attaining marketable size within 18 weeks as against 12-13 months in wild population.

c) Protracted breeding and continued settlement of spat ensures prolonged recruitment, which finally can give rise to 3 harvests in a year.

d) Mussels being feeding on microscopic algal and detrital matter occuring abundantly in tropical seas there is no necessity for the use of artificial feed and thus a substantial saving in operational cost and recurring expenditure, can be exercised.

e) Being almost immobile, culture and harvesting becomes cheap and easy.

f) As the species can withstand a high degree of atmospheric exposure, marketing it "live" is possible.

g) The high production of quality seafood in unit time and area guarantee a very substantial return on the investment.

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h) Small initial and low operational cost, simple technique, involving unskilled labour and a good market demand made the raft culture of mussels, an appropriate technology, both technically and economically.

Mussel culture, therefore, besides being highly profitable offers the best scope for utilization and management of resources. In fact, if the mussel culture is taken up as an industry on medium to large scale basis all the calculations of yield and profit will become an underestimate.

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TABLE 1

Details of Raft Culture Of Mussels in Goa

Time taken for commercial production	.. 18 weeks
Average marketable size of mussel	.. 62 mm
Average Weight of marketable mussel	.. 24 g with shell or 12 g meat
Number of 3 m ropes per raft	.. 50
Average Production per rope in 18 weeks	.. 18 kg mussels or 9 kg meat
Annual production per raft (6.25m^2 area with 50 ropes)	.. 2300 kg
Annual production of meat per m^2	.. 184 kg
Annual production per hectare (By Computing1/4 area of water occupied by Raft-each of 6.25 m^2)	.. 480 tonnes

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TABLE 2

Investment, Return And Profit In Mussel Culture In Goa

		Amount
1.	COSTS:	
a)	Direct Cost:	
i)	Material for fabrication of raft including wooden poles, planks, bamboos, drums, paints etc.	Rs 450.00
ii)	Anchor, mooring chains etc.	Rs 750.00
iii)	Rope and other materials	Rs 200.00
iv)	Labour charges for fabrication, transportation and anchoring	Rs 150.00
	Sub Total	Rs 1,550.00
b)	Indirect Cost:	
i)	Servicing and upkeep of raft (per annum)	Rs 200.00
ii)	Travel and Overtime to staff	Rs 200.00
iii)	Unforeseen expenditure	Rs 200.00
iv)	Depreciation of raft and other materials (per annum)	Rs 300.00
	Sub Total	Rs 900.00
	Total cost	Rs 2,450.00
2.	RETURN	
	Value of mussel per raft (from Table 1)	Rs 6,900.00
3	PROFIT	
i)	Value of produce	Rs 6,900.00
ii)	Cost of production	Rs 2,450.00
iii)	Gross profit	Rs 4,450.00
4.	Rate of return on Investment	181%

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TECHNICAL SESSION V. SHELLFISH DISEASES AND CONTROL | CMFRI-CAS/MF/80/BP-18

PREDATION AND FOULING PROBLEMS IN MUSSEL CULTURE

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INTRODUCTION

Predation and competition for food and space, attack on shell valves by boring organisms, parasitic infestation and disease out-breaks are all some of the important factors causing economic loss to the mussel farmer because of the large scale destruction and mass mortality of the cultivated stock. Therefore in developing culture technology and in the actual farm management considerable research effort has gone in to study the various facets of the problem in order to evolve suitable strategies to tackle them by adequate preventive and curative measures. The scope of this paper is limited to considering the problems of predation and fouling in respect of mussels.

Predation is one of the potential factors for the disappearance or destruction of the natural as well as the tended stock. In natural system, depradation may start with

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the larval population and continue to affect upto the fishable stock. But in the culture system the seeded stock on ropes/stakes/racks or the full grown individuals in the farm may suffer most. Many species of marine invertebrates and vertebrates feed on mussels. Similarly fouling organisms including many marine forms pose problems in natural beds as well as in the farm. These foulers attach to the fully or partially submerged surfaces of structures and grow in profusion thus creating competition for either space or food or both.

PREDATION

Natural beds:

The larval stages of mussels undergo the usual vicissitude of falling prey to plankton feeding animals and the surviving stock metamorphose and settle down as spat. Polyclad worms, littoral gastropods, star fish, crabs, lobsters and fishes take a heavy toll of the juveniles as well as adult individuals. The dog whelk, Thais, a littoral gastropod predator in Europe feed heavily on mussels of rocky shores. Urosalpinx, Acanthina, Ceratosama, ocenebra and Jaton species are also known mussel predators. Asteroid star fishes are among major predators throughout the world. Asterias rubens and A. forbesi play havoc destroying O-year class as happened in U.K. in 1975. In Denmark, sea-star is considered less of a serious predator. In Ireland Marthasterias glacialis is known to feed on transplanted stock of Mytilus edulis. Stichaster feeds heavily on Mytilus canaliculus in New Zealand and Pisaster ochraeus on M. californianus on the Pacific coast of U.S.A.

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The crabs Cancer and Carcinus take mussels in their diet. Edwards (1968) and Davies (1969) showed heavy mortality of plantigrades due to crab predation. Of the fishes that prey on mussels the golden mackerel Sparus aunata (Andreau, 1969) is known well. The flat fish (Pleuronectes spp.) also feed on young mussels. On off-shore beds, diving ducks and oyster catchers (Haematopus sp.) and other birds prey on intertidal mussels.

Mussel farm:

Predation of the farmed mussels is considerably less, especially in the hanging culture system. In France the sting ray 'Tere' (Trygon pastinaca) invades the mussels grown on stakes. The damage done to the mussel stock on ropes hung from rafts in Spain by the sparid fish Diplodus sarqus has been reported (Korringa, 1976). It is also believed that Aurata aurata can destroy mussels grown in Parks in Italy. In Philippines, Australia, New Zeland, Yugoslavia and other countries fish predation does not seem to pose any problem. Very recently Appukuttan (1980) has reported mass destruction of Perna indica grown on ropes in the west coast of India by shoals of Rhabdosargus sarba which fed voraciously on the adult mussels. During the experimental transplantation of Perna viridis and P. indica attempted along the Tuticorin coast in India the seed mussels were devoured by Siganus sp. and Gaterin sp. Predation by lobsters has also been observed in the west coast of India.

Among gastropod predators Nucella lapillus (Spain coast) and Rapana thomasiana (Black-sea) have been reported. The seaurchin, Paracentrotus lividus (Spain) and Salmacis sp. (India) pose minor problems.

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FOULING

Natural beds:

In Spanish rias the ascidian Ciona (Andreau, 1968) are stated to be a serious competitor for space. The synascidian, Diplostoma sp., Ascidiella, Botryllus, and Herdmania species are the other tunicates which are common foulers. It may not be out of place to mention that a list of 100 ascidians figuring in fouling and its prevention has been given by Woods Hole Oceanographic Institute in 1952 indicating their potential importance, although not sufficiently abundant to be harmful. In India Diandrocarpa brackenheilmi and Polycarpa sp. seem to be common, apart from Herdmania spp.

There are many encrusting, creeping, soft-tube building and hard-tube building forms, plants, animals and plant-like animal growths which settle down increasing the complexity of the fouling community. The problem of fouling appears to be serious in tropical and warm temperate waters, where the growth is rapid. Many of these forms have nuisance value and a few like Molialus spp, and Crepidula fornicata are serious competitors for space. Plants like Colpomenia sinuosa, Ulva lactuca and Codium sp. are also reported to create problems by profuse over-growth. The enormity of the fouling problem is such that, as Weiss (1948) stated, that a bucket of foulers when allowed to grow to maturity would weigh as high as 301.0 t.

So far as India is concerned the most common forms (Purushotham and Rao, 1971) in the mussel bed areas are as follows:

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(i) Coelenterates:- Laomedia bistriata, L. spinulosa, Bimeria franciscana and Pennaria sp; Sea anemones.

(ii) Annelida:- Calcareous tubes of serpulids Mercierella sp. Serpula vermicularis, Hydroides norvegica, Parchment tubes of sabellids and free living species like Perinereis cavifrons.

(iii) Arthropods:- Balanus amphitrite, B. tintinnabulum tintinnabulum, Cthamalus stellatus, Amphipods and Isopods like Corophium triaenonyx, Melita zeylanica, Cirolana, Sphaeroma, Metaponorthus and crabs.

(iv) Ectoprocta:- Bugula, Electra, Schizoporella and Zoobotryon species, Amathia distans, Crisia, Membranipora and Bowerbankia species. These are next in abundance to barnacles.

(v) Molluscs:- Anomia sp, Crassostrea cucullata, Modiolus striatubus, M. barbatus.

(vi) Tunicates:- Herdmania spp., Botrylloides sp., Botryllus sp., Polycarpa sp. Diandrocarpa sp.

(vii) Filamentous Algae, Padina, Codium, Valoniopsis sp. Hypnea sp. and Halimeda sp.

Mussel farm:

The pattern of settlement of foulers resembles the fouling in natural beds excepting that the complexity is increased because of the change to the three-dimensional environment. The succession of animal communities and intensity of fouling varies from season to season and from

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one geographical area to another. Therefore the problems faced by the culturist can be solved by studying the local conditions and devising proper methods to minimise the ill-effects of fouling community.

REMARKS

The question of mussel predation by fishes and crabs has not so far assumed serious dimensions in many countries practising culture. But this should not give room to complacency since the depredation, even though sporadic, might wipe out harvestable stock thus affecting production. Hanson (1974) suggests several methods, like air barriers, electrical barriers, acoustical barriers, animate barriers and chemical control to contain the menace. But in a country like India introduction of barriers technique is not possible in the present stage of development and economy of the industry. Sea-star menace is comparatively absent even in the natural beds and in raft culture the bottom living animals do not hold out much threat. However there is one source of predation to be guarded against namely the polyclad worms which are commonly noticed on the culture ropes. On many occasions planarians had been found wriggling inside the empty shell valves of mussel seed and adults. Whether the mussel flesh had been eaten away by them or it is a case of the worms occupying dead shell valves is not clear. However polyclads are known oyster enemies according to Bromhall (quoted by Davies, 1968) and mussel meat may also quite possibly fall within their diet range.

The restrictions imposed by fouling organisms can be tackled by inexpensive methods. Some of the methods followed in containing these are 1. Exposure of the culture ropes to

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atmosphere. In the fixed cultivation in the Gulf of Trieste, Favnetto (1968) states that all foulers except barnacles are killed by leaving the ropes out of water in the shade for a day. The ropes are then replaced in water. Lambert (1939) describes similar method for French Mediterranean coast also. Hs.Brenko and Igic (1968) recommend immersion in fresh water for not longer than a day. Desirable biological and chemical controls have been suggested and followed in many areas of the world. Treatment of rope with I.D.T. spray before seeding also may be useful to keep down fouling intensity. Periodical cleaning of the stock and removal of undesirable growths is also recommended, especially during seasons of peak fouling.

Where the question of fouling is not on the mussel stock but on the wooden raft structures or on the oil barrel floats caution needs to be exercised in proper maintenance like painting or by coating them with anti-corrosive and anti-fouling paints. Thus heavy boring by Teredo can be kept down as otherwise the raft might not be strong enough to withstand wave-beating and might in due course disintegrate. From the foregoing account it is clear that predation control and antifouling measures are important aspects needing careful action.

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TECHNICAL SESSION VI	POST-HARVEST TECHNOLOGY AND MARKETING	CMFRI-CAS/MF/80/BP-19

PUBLIC HEALTH ASPECTS OF CULTURING AND PROCESSING OF MUSSELS AND OYSTERS

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I N T R O D U C T I O N

The culture of mussels, oysters and clams in shallow and intertidal areas in the inshore coastal and estuarine waters is being practised widely in developed countries to supplement the animal protein resources for human consumption. Spain, U.S.A., Japan, Canada and France have made notable progress among the nations who have taken to the bivalve culture. Of the average annual production of molluscs in the world of about 3.5 million tonnes, India's contribution is a meagre 2000 tonnes. There are extensive mussel beds along the rocky coasts of India and the clams and oysters in some of the estuaries and backwaters offer great scope for development.

FOOD VALUE

The value of the meat in the bivalves depends on its nutritive value. The chemical composition of the meat of oysters, mussels and clams is broadly as follows:

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	Moisture %	Protein %	Fat %	Ash %
Oysters (*Ostrea* sp.)	76.8	11.2	1.9	2.0
Mussels (*Mytilus* sp.)	83.3	10.2	1.6	1.9
Clams (*Meretrix* sp.)	75.2	10.3	2.1	2.1

The above molluscs are also very good sources of glycogen and minerals like calcium, phosphorus, iron and iodine, besides vitamins 'A' and 'B'. (Venkataraman and Chari, 1951).

CULTURE, ENVIRONS AND HEALTH HAZARDS

The culture production of the bivalves as well as production from natural beds pose some problems which have to be taken note of when these are harvested, processed and marketed. These molluscs are the most easily contaminated due to the nature of their habitats. Oyster and mussel beds are a potential hazard to public health on account of possible epidemic infections being carried by the shell fishes.

They are to be cultivated in areas which are away from possible sources of contamination like sewers, bathing places, drains, oil jetties, etc.

The oyster and mussel beds are invariably located along the coast and especially in river mouths with tidal and rain water movements. This provides the risk of dangerous contamination by pathogenic bacteria present in such environments. These bivalves filter the water of the

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environment but retain a substantial part of the bacteria present. They are sometimes eaten raw and if these bivalves are cultured in environments of insanitary conditions and if these are not properly treated or purified before being consumed raw, a serious health hazard due to bacterial food poisoning will result. The pathogenic organisms in contaminated sea water areas have been variously reported as Salmonella, Vibrio parahaemolyticus, Steptococci, E.Coli, Aerobacter aerogenes, Proteus, Para colon bacteria and Clostridium sp.

Another type of contamination or pollution of the oyster and mussels can be by heavy metals from industrial effluents. Arsenic, iron, cadmium, copper, zinc, lead, mercury are some of the metals reported to be absorbed by mussels. Radio active wastes let into the sea can also be a health hazard to the mussel as well as to the consuming public (Roberts, 1976).

There is an instance of bacterial mussel pollution reported by Venkataraman and Sreenivasan (1955) near Calicut. Faecal pollution (E.Coli type I, Paracolons and Proteus) has been observed in the mussel of the bivalve mainly during the South West monsoon (June-August) when the rain water carries the town refuse into the sea. Salmonella-shigella organisms were absent and so also vibrios.

Another health hazard can be from pesticides. Mussels are known to assimilate these organochlorines (D.D.T.), Endo sulfan, Toxaphene, Parathion etc.) washed

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into the beds from agricultural drainage by storms, which can be a risk to the consuming public if the meat of such bivalves are consumed raw or without any treatment before consumption, as such pesticides while not likely to be toxic to the bivalves can affect the consuming public.

Yet another type of health hazard reported elsewhere, though not in our country, is the paralytic shell fish poisoning due to comsumption of the meat of mussels and oysters taken from beds during certain periods of the year when there was a bloom or heavy growth of planktonic organism. Dinoflagellates of the genus Gonyaulax are chiefly associated with the paralytic toxin formed in filter feeding molluscs. (Halsted, 1965; Robinson, 1968). Other organisms like Prorocentrum, Exuviaella and Gymnodinum sp. have also caused poisoning (Ingham et al, 1968). Normally these dinoflagellates are harmless, but when the blooms occur, (the so-called 'red tide'), vast number of the organisms are taken in by the filter feeders which accumulate the toxin in their flesh. If such affected shell fish are eaten by the public, the outcome can be serious, resulting in neurotoxic symptoms and occasionally death. (Halsted, 1965). The poison extracted from the mussel meat and the incriminating dinoflagellates seems to be a heat resistant alkaloid with muscarine-like action and a potent neurotoxin. It has also a depressant action (Pepler and Loubster, 1960). In our country, poisoning due to consumption of mussels or oysters of this nature has not been reported, though discoloration of patches of sea water due to blooms of Noctiluca, Trichodesmium, Hornellia

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marina and even Gymnodinum have been reported sporadically. (Subramanian, 1954; Prakash amd Sharma, 1964).

BACTERIAL POLLUTION IN OYSTERS AND MUSSELS AND PROCEDURE FOR RENDERING THEM SAFE

The fish feeding bivalves have a tendency to concentrate the coliform bacteria from the sea water and this fact underlines the public health significance of oysters as potential agents of enteric infection.

While it is advisable to culture oysters and mussels in unpolluted or 'safe' water spreads, it is difficult to avoid completely the pollution in such areas. So they must be marketed after a systematic cleaning since they are consumed raw. The cleaning or depuration methods are based on the principle that molluscs contaminated with Entero-bacteria free themselves from these bacteria within 24 to 48 hours when they are placed in water of sufficient salinity and devoid of bacteria. Chlorinated water subsequently dechlorinated is used. (Dodgson, 1928). This technique of chlorine treatment is now being replaced by ultra violet light or ozone treatment. Relaying of oysters before marketing in clean beds which are certified to be non-polluted has also helped the aqua-culturists to get a safer product. This technique can be adopted as a batch process ie. holding the bivalves in tanks where the seawater after chlorine and dechlorination treatments are filled in and kept for 12 hours whereafter the water is drained and refilled with a fresh batch of pure sea water. In the continuous process the pure sea water is allowed to flow through the holding tanks continuously where the

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bivalves are kept and the purification can be quickened by this procedure. In view of the similarity in the physiological functions among the bivalves, the methods applicable to cleanse oysters of harmful organisms can also be applied to others like mussels, clams, scallops, abalones etc.

MARKETING AND PROCESSING

Shellfishes are not only the most perishable of sea foods but also are the most easily contaminated due to the nature of their habitat.

A great many soil and water bacteria which apparently had no effect on oysters are found in the decomposing oyster meat.

Decomposition of the shucked meat from the shell fishes is due to the activities of spoilage bacteria as commonly found in fish like Pseudomonas, Achromobacter Escherichia, Micrococci etc. Methods of preservation must be directed towards this flora.

Pathogens when present in large numbers, survive freezing and cooking. Cooking should be vigorous if it is to kill E.coli and it may be impossible to remove the E.coli from the meats of the polluted shell fishes by washing alone. These bacteria are responsible for causing infections like diarrhoea, gastro-enteritis etc.

Bulk of the oysters and mussels are marketed in live conditions after the depuration process in most of the countries, since oysters are consumed raw while the mussels are cooked and utilised immediately.

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The meat from the mussels and oysters are shucked and washed well to remove sand, shell particles etc. and chilled in containers in ice boxes. The meat is marketed in this way for local consumption.

The shucked meat can also be cooked and frozen as for fish slices or prawns at -40°C and held in frozen storage at -23°C upto about 44 weeks for marketing as frozen molluscan meat.

George (1974) has shown that during freezing and storage of the frozen mussles, the total bacterial load comes down by 99% and the pathogenic germs like E. coli and faecal Streptococci are completely destroyed at the end of 44 weeks of storage at -23°C.

Canning of mussel meat in oil has been experimentally attempted at the Central Institute of Fisheries Technology (Balachandran and Nair, 1975) with promising results. Light smoke curing of mussels and drying to a moisture content of 10% after self purification of the live shell by giving a starvation treatment for one day to eject the sand in the meat followed by immersion in chlorinated water (5 ppm) for 2 hours has been reported by Muraleedharan et al (1979).

Mussel meat may be stewed, roasted, fried, creamed, pickled with vinegar or made into fritters and chowder.

Pickling is a common way of preservation of mussel meat. It is also used as a bait.

Mussels can be converted into protein concentrate (protein 70%) after isopropanol extraction.

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Blue mussel meat is also used as a valuable feed for pigs in some areas of Russia. In Thailand, young mussels are harvested from the bamboo collectors and used as animal feed.

In the context of the development of brackish water spreads for molluscan aquaculture for supplementing the marine food resources, the following investigations are required to be carried out in our country as very little information is available at present.

(i) Survey of the grounds suitable for culture of the molluscs especially oysters and mussels with particular reference to the extent of pollution of these areas by industrial effluents, pesticides from irrigation drainage systems, and by pathogenic organisms and the identity of such organisms.

(ii) A depuration technique must be worked out and standardised to make the consumption of oysters and mussels safe for human consumption.

(iii) Research on such methods of preservation of the meats of these molluscs like drying, salting, pickling, freezing and canning and development of diversified products with these meats as the base may have to be intensified and the consumption of oysters and clams popularised among the masses.

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TECHNICAL SESSION VI POST HARVEST TECHNOLOGY AND MARKETING | CMFRI-CAS/MF/80/BP-20

TECHNOLOGY OF PROCESSING MUSSEL MEAT

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INTRODUCTION

Green mussel (Perna viridis) and brown mussel (P. indica)are available in substantial quantities from their natural beds along the south-east and south-west coasts of India respectively. Mussel is locally collected for its meat which is consumed in the nearby areas. Mussel meat normally finds favour with people of low income group and that too when the fish is scarce or costly, which often results in poor economic returns to the collector. There are quite a large number of people engaged in its collection and, they together with the middlemen and the actual vendors in the market and their dependents constitute a large number of people earning a living from mussel. Any poor respose from the market directly affects the economic and social status of these people and in turn their region as a whole.

Why product development is necessary?

Even in the absence of accurate statistical information about the availability of wild cultured mussel, it is well known that there is the potential for a very large sustainable quantity available from the

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natural beds, the present rate of exploitation being far less than the potential availability. The recent tempo in its culture stands a sure guarantee for continued abundant availability. Capture along with culture promises a greater quantity flooding the markets which, if not met with ready demand from the consumers, will result in a further fall in its value as also wastage.

Mussel meat, like fish, is a highly perishable commodity. One of the ways of ensuring reasonable returns to the producer is to convert the mussel meat into stable processed products and market them in far off areas from the collection centres.

Popular processed products from mussel meat

There are several processed products known to be popular in several overseas countries, particularly Europe. Canned, frozen, marinated and light smoked and dried are some of the most popular processed mussel products. Mussel meat canned in oil or brine and pickled either in brine or vinegar with or without heat processing are widely used. If products conforming to the requirements of overseas markets can be processed, mussel meat can even find ready demand from such markets. Prospects of transportation of fresh mussel or meat to distant areas can be given a fair trial. We have recently developed processes for converting mussel meat into stable processed products. Adoption of these for prolonged preservation and wider distribution, coupled with transportation of fresh mussel or meat are sure ways of ensuring adequate returns to those engaged in the trade and thus enhancing their economic status.

STUDIES ON PRODUCT DEVELOPMENT

1. Purification

Mussel is a sedentary animal found in the littoral and sublittoral zones where they are attached to rocks by means of byssus threads. They feed by the mechanism of filtration of microscopic food materials suspen-

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ded in the surrounding water. At any given time their stomach will contain a lot of sand and other gritty materials which, if allowed to remain, will inpart grittiness to the end product. Besides, the coastal waters are likely to be polluted by sewage water, industrial effluents as well as human faeces. Contamination of the water and hence the mussel with faecal and pathogenic bacteria, and to a lesser extent with heavy metals cannot be ruled out. Paralytic shell fish poisioning, though not frequent, is known to occur in bivalves in Atlantic waters. However, this is not considered so significant in waters of tropical regions. One of the most important prerequisites of any type of processing is to purify the mussel.

If the mussel is bacteriologically polluted its purification is rather simple since the mussels cleanse themselves of all polluting bacteria if they are kept in clean sea water for a number of hours. In some places mussels are kept in clean sea water in tanks over two nights with a change of water on the second day (Waterman). The same treatment can also free the mussel of most of the sand from their stomach. It has been experimentally proved that mussel kept alive in sea water for 24 hours followed by chlorination at 5 ppm level brings down the sand content to 0.02% on dry weight basis of the meat (Balachandran and Nair, 1975). No faecal or pathogenic bacteria have been detected in so purified mussels. However a continuous monitoring of the quality of meat and water in the surroundings with respect to incidence of pathogenic and faecal bacteria as well as contamination with heavy metals is absolutely necessary. The practice of keeping them in cleaning tanks on the shore or of keeping them in cages or net bags on platforms left under water in clean areas for few days appear recommendable processes for cleaning mussels. It will be ideal for greater safety to check all batches of mussels so cleaned for any probable incidence of paralytic shellfish poisoning before releasing for processing.

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2. Product development

i)Products for sophisticated markets

a) Canning Mussel meat has been found to render itself well for canning. The purified mussel is either heated in open vats or steamed in an autoclave and the meat is shucked out. The shucked meat is washed in water and blanched in 5% boiling brine for 5 minutes. Blanched meat is packed in cans, filled with either hot brine or oil, exhausted, seamed and heat processed followed by cooling. This method has been found to yield a products with good organoleptic and keeping qualities (Balachandran and Nair, 1975).

Under the conditions obtaining in South India the availability of mussel meat being at places far away from the probable centres of canning, processing always incolves an element of transportation over a considerable distance. Though transportation of live mussel appears ideal, it involves the transportation of the bulk of shell which is a waste material and thus adding to the cost. Therefore some studies have been undertaken on the shelf life of mussel, whole or meat, and transportation of whole mussel and meat in ice under different conditions subsequently to be used for canning. These studies have proved that canned products prepared out of whole mussel or fresh shucked meat yielded canned products with good organoleptic characteristics when iced and stored upto 2 days. These products had better colaur, flavour and juiciness of the meat compared to canned meat prepared out of similarly iced, stored, boiled and shucked meat (Balachandran and Prabhu, 1980).

b) Freezing

Relatively little work has been carried out in the field of freezing mussel meat. Chinnamma George (1974) working on the frozen storage characteristics of mussel meat reported that frozen meat prepared out of whole mussel iced stored for 8 days remained in acceptable condition only upto 15 weeks whereas fresh frozen meat remained in acceptable condition for 40 weeks.

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ii) Importance of mussel meat in human nutrition and product development involving low cost technology for the local markets.

Meat of green mussel (P. viridis) has the following proximate composition

Moisture %	78.24 - 80.28
Protein %	11.08 - 12.61
Fat %	2.38 - 3.02
Glycogen %	5.36 - 7.91
Ash %	3.06 - 4.21

The sweet flavour of mussel meat, owing particularly to its relatively high content of glycogen, is comparable to that of prawns, crab etc. That is much cheaper compared to the price one has to pay for the above commodities at the same time meeting same or similar nutritional requirements makes mussel meat poor man's delicacy. Wider distribution of mussel meat into areas where there is deficiency of protein in the diet of people, can go a long way in bridging the protein gap particularly of animal protein. This requires the development of low cost technology for preparation of inexpensive stable processed products. This aspect is engaging the attention of scientists and technologists and a number of such products have already been developed.

a) Dried mussel meat

The cheapest method of preservation applicable to mussel meat to yield a stable product with reasonable shelf life if drying. Meat shucked from fresh purified mussel after blanching in 5% boiling brine for 5 minutes is dried by spreading in trays either in sun or in an artificial dryer until the moisture level reaches 10% or below. After allowing the moisture to equlibrate by keeping in a closed container for a day or two it can be packed and distributed. The storage life of this product has been estimated to be around six months. After reconstituting by soaking in water for 30 minutes this can be used for any culinary preparation as is done with fresh meat (Anon, 1980).

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b) Smoked and dried mussel meat

A product for which there already exists demand from overseas markets and also can have demand from the domestic consumers is light smoked and dried mussel mat. Method of preparation involves drying of blanched mussel meat in the sun or artificial dryer for an hour (until the moisture level comes to 40-45%) followed by smoking in a kiln for half an hour and further drying to a moisture level of 10% or below. After equilibration of the moisture in the dried product as is done for dried mussel meat, the product can be packed for distribution. Light smoked and dried mussel meat tastes better compared to heavy smoked one. Hence cold smoking for a shorter period is ideal for this. Coconut husk and saw dust can be employed as source for generating smoke (Muraleedharan, Nair and Joseph, 1979).

c) Mussel meat pickle

Another product involving low cost technology for processing and which can meet with ready demand from the consuming public is mussel meat pickle. There are several pickles made with vegetables, fish, prawns etc. already popular in the market. Demand for diverse type of pickles is ever increasing, particularly from the urban population. Method has been worked out for preparing mussel meat pickle having a shelf life upto six months. A recipe for the pickle now being popularised is as follows:

1. Blanched mussel meat (of which the stomach is cut out)	-	1 Kg
2. Refined salt	-	80 g (dissolved in 400 ml boiled and cooled water)
3. Green chilly (cut into small pices)	-	80 g
4. Ginger (skinned and chopped)	-	70 g
5. Garlic (skinned and mashed)	-	50 g
6. Chilly powder	-	75 g
7. Turmeric	-	2 g
8. Mustard seeds (Powdered)	-	15 g

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9. Sesame oil	- 250 g
10. Vinegar (3-4 ml of food grade acetic acid in 100 ml boiled and cooled water	- 250 g
11. Curry leaves	- as required

Method of preparation

Blanched meat after cutting off the stokach portion is made into three or four small pices and is fried in oil in low flame until the colour turns brown. Green chilly, ginger, curry leaves and garlic are fried in the oil remaining in the pan after removing the fried meat. Then are added chilly powder, turmeric powder and mustard powder and the contents stirred well. Salt solution is added to the mixture and brought to boiling. The fried meat is added to this mixture, the pan is removed from the flame and when sufficiently cool is mixed with vinegar. The pickle is stirred well to make it uniform, cooled and packed in dry clean glass bottles. Care should be taken to see that no solid portion is left exposed. A layer of oil should be present at the top in the finally packed samples, (Muraleedharan, George Joseph and Devadasan 1980).

d) Mussel meat 'Chutney' powder

A delicious product which can be consumed as appetizer along with the South Indian preparation of 'dosai', 'iddli' and the like, mussel meat chutney powder, is easy to prepare, handle and store. The method of preparation employing the following recipe is as follows:

Recipe

Dried mussel meat	- 500 g
Skinned black gram	- 500 g
Red chilly	- 75 g
Coriander	- 50 g
Asafoetida	- 5 g
Refined Salt	- to taste

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Dried meat is fried well in a pan until the colour turns brown. Other ingredients except salt are separately fried in order to render them ready for powdering. All the ingredients are powdered well by pounding and mixed together with sufficient quantity of salt. The chutney powder so prepared should be packed in dry polythene bags or dry air tight bottles for safe storage. Mixed well with little warm coconut oil at the time of use this yields a delicious chutney. (Anon, 1980).

e) Marinated mussel meat

A product which involves low cost technology in processing and is already popular in overseas markets is mussel meat marinated. A method of processing marinated mussel meat reported from U.K. is as follows. Live mussel is held in boiling brine for 4-6 minutes depending on size. Meat after shucking is held in weak brine containing 2-3% salt for 2-3 hrs, drained and then packed in containers, typically glass jars, and covered with vinegar containing 4-6% acetic acid. The vinegar for covering mussels is often spiced before being added (R.McLay).

Studies are underway at the Central Institute of Fisheries Technology to work out a suitable process of marinating mussel meat having desirable organoleptic characteristics and good storage life.

NEED FOR EXTENSION WORK IN POPULARISATION OF MUSSEL PRODUCTS

Presently mussel meat is consumed fresh only in areas at or around the collection centres. People in other areas, more often than not, are not aware of this commodity as a nutritions food material, nor has any attempt since been made in popularising it in such areas. It is only recently that some attempts have been made to preserve mussel meat into stable processed products by the application of low cost technology so that the commodities will well be within the purchasing capacity of rural population. Any new product coming to the market, particularly

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based on raw materials like mussel, clams, oysters etc which are supposed to be low cost food of poorer section of the population, is likely to meet with some consumer resistance. Therefore it calls for an exhaustive extension programme to educate the people of the importance of mussel meat as a protein rich food material and about the ways of consuming it. There should also be a regular system of monitoring feed back information on the consumer's reactions particularly regarding the acceptability of the products and the type of improvements they would desire to have on the product as a whole so that the scientists can devote their attention in improving them without deteriment to its nutritional quality and without additional drain on the pocket of the consumer.

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CENTRAL MARINE FISHERIES RESEARCH INSTITUTE
COCHIN - 682 018
CENTRE OF ADVANCED STUDIES IN MARICULTURE
WORKSHOP ON MUSSEL FARMING
MADRAS 25-27 SEPTEMBER 1980

TECHNICAL SESSION VI	POST-HARVEST TECHNOLOGY AND MARKETING	CMFRI-CAS/ MF/80/BP-20a

MARKETING OF MUSSEL AND ITS PRODUCTS

The aspects such as production characteristics, demand and consumption pattern, trading practice and nature and form of the products determine the marketing prospects and potentials of any commodity. The mussel fishery of our country is composed of two principal species, namely, the green mussel (Perna Viridis) occurring all along the coasts and the brown mussel (Perna indica) having a restricted distribution from south of Quilon to Kanyakumari on the west coast and along Tirunelveli coast on the east. The mussels exploited at present in our country forms only a subsistence fishery. They are fished mainly from Varkalay near Quilon to southern Karnataka coast. Along the Tamil Nadu coast, they are fished from Colachel to Kanyakumari. The important fishing centres are in the Calicut - Cannanore zone, at Vizhinjam, Colachel-Muttom and Kanyakumari.

There is no reliable statistics on the annual production of mussels realised from various centres. However, it is estimated that about 3000 metric tons of mussels are landed annually, the bulk of the landings coming from Calicut - Cannannore and Vizhinjam to Muttom

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regions. The main season of the fishing is from November to May in the Centres on the west coast and from January to September on the east coast.

The mussels that are landed are marketed at present at the landing centres or in the nearby markets in fresh condition with shell on. They are normally sold in counts of hundreds. The market price varies from place to place and depends on the quality (size) of the mussel, its availability and also the abundance and fluctuation of other fishes.

There is no organised marketing system for mussels in India. Because of the relatively small quantity of mussels landed at present, marketing of the products does not pose any serious difficulty. However, it is envisaged that large quantities of mussels could be produced by the intensive culture in the open seas, as well as in the coastal waters as indicated by the techno-economic studies and demonstrations carried out at different centres.

The marketing of fish or any commodity which has an established acceptability or forms an epicurean gourmet pose no problems. However, the mussels in our country is considered as poor man's food and as a 'lesser species' having poor demand and acceptibility in the market. This is largely due to the prevailing prejudices and preference and non-availability of the commodity in the form required by the consumers. However, in view of the great utility of mussels both from nutritional and economic points of view, the Workshop may discuss the various aspects of marketing of mussels as well as the constraints encountered and may consider,

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1. The urgent need to carry out a comprehensive market research/survey to establish a viable marketing base for mussels that could be produced from culture source;

2. As the mussels could bridge the protein defficiency in the Indian diet and could contribute greatly to improve the income of fishermen/fish farmers as well as the rural economy, there is an imperative need to improve the demand and marketability of mussels through proper extension and education of the consumers.

3. Marketing functions of mussels could be taken up through Fisheries Cooperatives/Corporations so as to ensure stabilised price and to the best advantage of both the producers and consumers.

4. Researches to produce diversified mussel products may be strengthened, so that the products preferred by the consumers could be made available and a sustained demand to the products could be ensured.

5. Internal market, particularly in the inland centres may be developed to market the commodity as mussel/mussel products are not available in far away places from the coastal areas.

6. External markets could be explored properly through marketing intelligence and Marine Products Export Development Authority may endeavour to export the commodity as mussel products could augment the much-needed foreign exchange through increased export of fishery products.

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TECHNICAL SESSION VIII	TRAINING AND EXTENSION	CMFRI-CAS/MF/ 80/BP-24

TRAINING REQUIREMENTS FOR THE ACCELERATED DEVELOPMENT OF MUSSEL FARMING

It is well recognised that the development and growth of any sector largely depend on the existence or availability of trained personnel. The technology of mussel culture practiced at present in countries like Spain, Netherlands, Italy and France has developed into a sophisticated one necessitating the knowledge of several, aspects of its operation, surroundings, post-harvest processing and preservation and disposal. Advances in the knowledge of biology, physiology and ecology of mussels and the environment in which they live and grow have helped greatly to obtain enhanced production. New material and engineering skill put in have enabled to design and construct viable farms and culture bases. Investigations on environment management, diseases and their control have helped to achieve higher survival rate and quality products. These as well as other technological progress made in the recent years have thus developed mussel culture to an important and specialised branch of aquaculture.

The organisation of an extensive/intensive mussel culture enterprise depends to a large extent on the

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efficiency with which the avocation is carried out and the personnel involved in it. The establishment of a mussel culture fisheries on modern lines requires trained personnel of different categories. Key categories of personnel required for effective development and stabilised growth of mussel culture industry are (1) Research and Technical personnel (2) Managerial personnel (3) Culture specialists (4) Coastal environmental specialists (5) Farm engineers (6) Processing technologists (7) Extension specialists and (8) Skilled operatives.

As indicated earlier, modern culture of mussels has developed into a multidisciplinary science involving the knowledge of biology, ecology, physiology, microbiology, nutrition, genetics, water chemistry, engineering and processing, pathology, economics, sociology etc. Research and technological personnel are required to undertake investigations in all these branches. Managerial and techno-administrative personnel having sound knowledge in the composite subject matters are needed to manage the farms and implement the schemes. The availability of species, culture site and its ecosystem, vary from place to place necessitating location-specific studies to evolve viable techniques of culture. This requires the services of competent culture specialists and environmental specialists. Open-sea farming of mussels warrants great engineering skill to construct and put up the culture platforms in the dynamic environment of the sea. Similarly the role of processing technologists in evolving consumer preferred quality products; extension specialists in the wide propagation of the system among the farmers and of the skilled operatives in the field of culture operation and fishing need not be emphasised.

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The training needs of above categories of personnel are varied. There is at present no Institute or Centre in the country which offers training on regular and/or Institutional basis on mussel culture. This is perhaps due to the reason that the culture system is just emerging as a means of large-scale production of mussels and it is yet to be established on commercial scale in our country. However, the importance of training/education to meet the manpower requirements as well as to accelerate the process of development needs no emphasis.

In our country, the Central Institute of Fisheries Education, Bombay, College of Fisheries, Mangalore and Tuticorin and the Centre of Advanced Studies in Mariculture at Central Marine Fisheries Research Institute are the important Institutes imparting education/training on Fishery Science. Researches on mussel are carried out chiefly at Central Marine Fisheries Research Institute, National Institute of Oceanography and in certain coastal Universities. Among these research Institutes the Central Marine Fisheries Research Institute is the pioneer Institute and has developed the basic techniques of mussel culture in the open sea and has demonstrated its techno-economic feasibility. Recognising the dearth of trained research and technical personnel in the field and the urgent need for filling up this deficiency, the Institute under its training projects and the recently established Centre of Advanced Studies in mariculture is offering both long-term and short-term training courses.

With a view to transfer the technologies evolved and perfected in the research Institutes to the farmers/ fishermen and to provide need-based training in different aspects of mariculture, a Farm Science Centre - Krishi Vigyan Kendra- was established at Narakkal under the

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Central Marine Fisheries Research Institute and this centre offers at present training on various aspects of prawn culture. The Kendra proposes to impart training on mussel culture shortly.

In the light of the above background, the Workshop may like to consider:

1. The need and pattern of education/training required to produce a cadre of qualified research/technical personnel to develop the mussel culture industry of India.

2. In certain fields such as Farm engineering, coastal environments and genetics, the expertise available in the country is inadequate and the need for some arrangement for training of such identified subject matter specialists may be discussed.

3. In view of the great potentials for the development of mussel culture in India and considering the large number of fishermen/fish farmers required to be trained to carry out the culture operation effeciently and that too in their local language, it may not be possible to the KVK at Narakkal, the only centre of its kind on the subject in the country, to train all the farmers. Intensive training facilities will have to be developed by each of the states under suitably organised programmes, so that, skilled operatives are available when other developmental facilities are put in the field.

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